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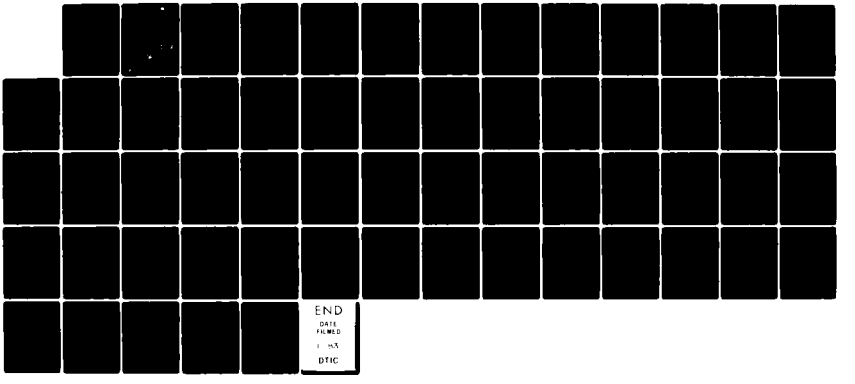

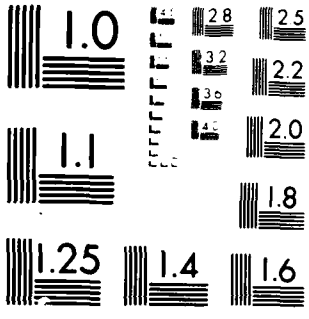

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An Axisymmetric, Numerical Model for a Non-Hydrostatic Boussinesq Ocean

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This report documents an axisymmetric, non-hydrostatic ocean model. The governing equations are first presented, and the finite difference (FD) form of the governing equations are developed for the fully staggered grid. The elliptic diagnostic equation for pressure is then derived and the associated boundary conditions are discussed. A listing of the FORTRAN codes of the model and a hydrostatic version of the model are attached. This model is useful for studies such as ocean response to circular wind fields or the secondary flow within Gulf Stream rings.

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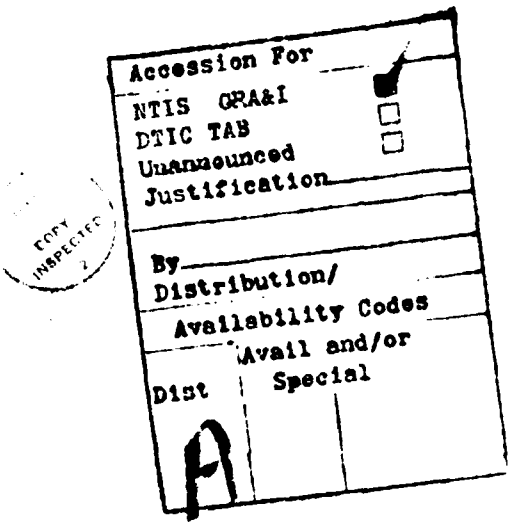

AN AXISYMMETRIC, NUMERICAL MODEL FOR A NON-HYDROSTATIC BOUSSINESQ OCEAN

1. GOVERNING EQUATIONS

The governing equations of the axisymmetric, non-hydrostatic, Boussinesq ocean model are

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial r} + w\frac{\partial u}{\partial z} = \frac{v^2}{r} + fv - \frac{1}{\rho_o}\frac{\partial p}{\partial r} + K_H\left(\nabla^2 u - \frac{u}{r^2}\right) + K_z\frac{\partial^2 u}{\partial z^2} \tag{1-1}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial r} + w\frac{\partial v}{\partial z} = -\frac{uv}{r} - fu + K_H\left(\nabla^2 v - \frac{v}{r^2}\right) + K_z\frac{\partial^2 v}{\partial z^2} \tag{1-2}$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial r} + w\frac{\partial w}{\partial z} = -b - \frac{1}{\rho_o}\frac{\partial p}{\partial z} + K_H\nabla^2 w + K_z\frac{\partial^2 w}{\partial z^2} \tag{1-3}$$

$$\frac{\partial b}{\partial t} + u\frac{\partial b}{\partial r} + w\frac{\partial b}{\partial z} = N_z^2 w + K_H\nabla^2 b + K_z\frac{\partial^2 b}{\partial z^2} \tag{1-4}$$

where $\nabla^2 \equiv \frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r}$, other symbols are listed in Appendix A. Above, the density anomaly b is defined according to

$$b = \frac{\rho - \rho_r(z)}{\rho_o} g \ , \tag{1-5}$$

where $\rho_r(z)$ is a reference density and is a function of depth only. Brunt-Väisällä frequency N_z is defined as

$$N_z = \sqrt{\left(\frac{-g}{\rho_o}\frac{\partial \rho_r}{\partial z}\right)} \tag{1-6}$$

Manuscript approved September 29, 1982.

The continuity equation is that of the incompressible fluid,

$$\frac{1}{r}\frac{\partial ur}{\partial r} + \frac{\partial w}{\partial z} = 0 \qquad (1\text{-}7)$$

2. THE MODEL GRID

It is determined that a fully staggered grid is most expedient for storage economy for a given spatial resolution. As shown in Fig. 1, the radial (u) and the tangential (v) velocities are defined at cross points, vertical velocities (w) are defined at open circle points, and the pressures (p) and density anomalies (b) are defined at blackened dot points. This grid system has the following advantages:

a) it saves storage for a given spatial resolution

b) it is very economical in terms of number of computational operations for the finite difference (FD) equations of (1-1) to (1-4).

c) it is very easy to specify the boundary conditions,

d) the pressure diagnostic equation, of the elliptic type, can be reduced to the standard form, and

e) there is no spatial separation of solutions on the grid.

In order to consistently index the grid points, we let index pair (ij) represent the i-th point in the r-direction and j-th point in the z-direction. In addition, m is the maximum number of points in the r-direction, and n, the maximum number of points in the z-direction. Therefore there are m x (n-1) points for radial and tangential velocities, (m-1) x n points for vertical velocities, and (m-1) x (n-1) points for mass distribution (b and p).

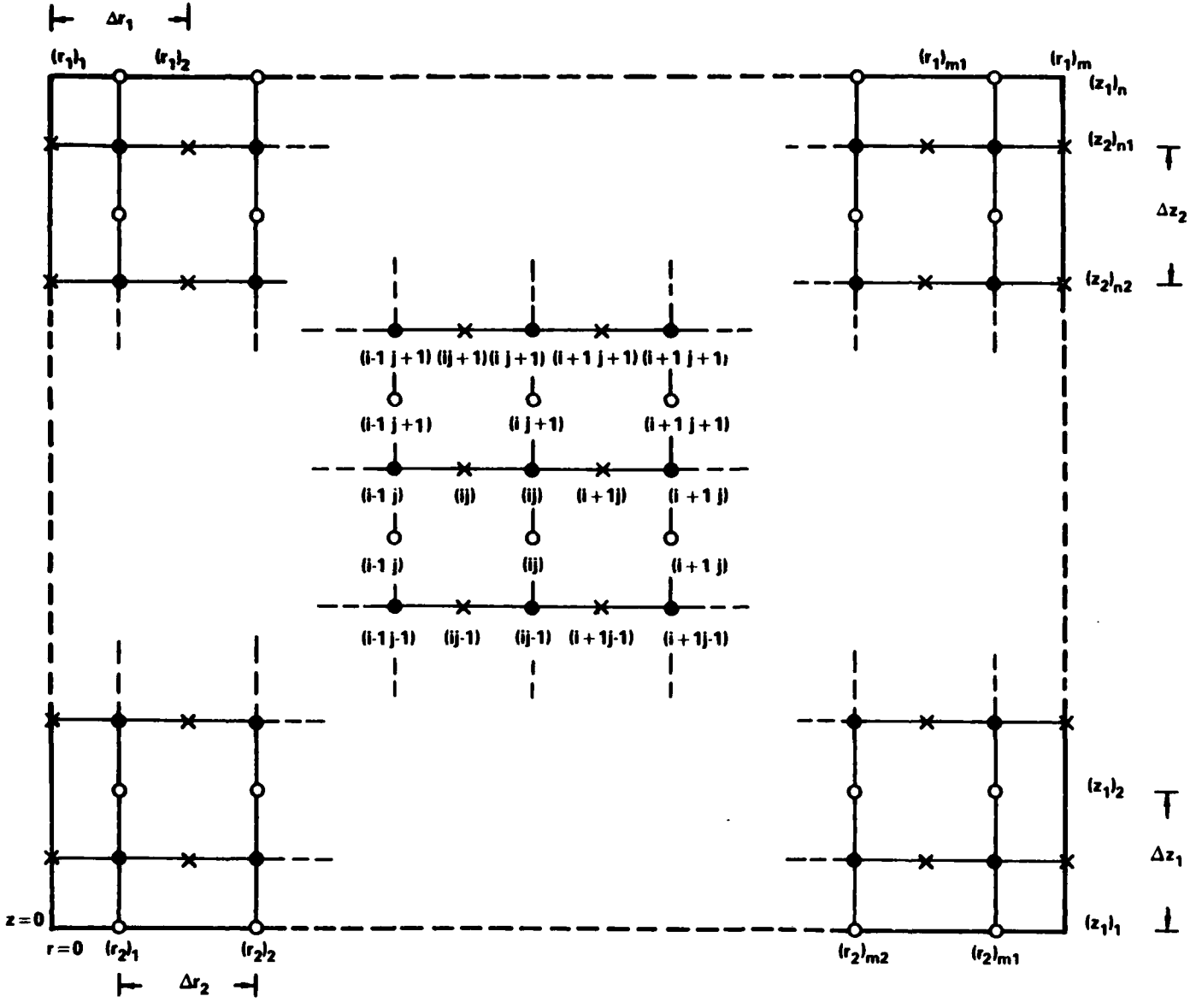

Fig. 1 The fully staggered grid system of the ocean model.

3. THE FINITE DIFFERENCE EQUATIONS

The leapfrog, or centered-in-time, integration scheme for the inviscid terms and the forward-in-time integration scheme for the viscous terms are used. The scheme is described as

$$\begin{Bmatrix} u^{t+\Delta t} \\ v^{t+\Delta t} \\ w^{t+\Delta t} \\ b^{t+\Delta t} \end{Bmatrix} = \begin{Bmatrix} u^{t-\Delta t} \\ v^{t-\Delta t} \\ w^{t-\Delta t} \\ b^{t-\Delta t} \end{Bmatrix} + 2\Delta t \begin{Bmatrix} \frac{\partial u}{\partial t}^{t} \\ \frac{\partial v}{\partial t}^{t} \\ \frac{\partial w}{\partial t}^{t} \\ \frac{\partial b}{\partial t}^{t} \end{Bmatrix} \qquad (3\text{-}1)$$

A second order, or centered-in-space, scheme is applied to derive the tendencies in (3-1) according to (1-1) ~ (1-4).

(a) The Equation of Motion in r-direction

$$\frac{\partial u_{ij}^{t}}{\partial t} = H_{ij}^{t} - \frac{1}{\rho_o} \frac{1}{(\Delta r_2)_i} (p_{ij} - p_{i-ij}) \qquad (3\text{-}2)$$

where

$$
\begin{aligned}
H_{ij}^{t} = -0.25 \Bigg[& \frac{1}{(\Delta r_1)_{i-1}} (u_{ij}^{t} + u_{i-1j}^{t})(u_{ij}^{t} - u_{i-1j}^{t}) \\
& + \frac{1}{(\Delta r_1)_{i}} (u_{i+1j}^{t} + u_{ij}^{t})(u_{i+1j}^{t} - u_{ij}^{t}) \\
& + \frac{1}{(\Delta z_2)_{j}} (w_{i-1j}^{t} + w_{ij}^{t})(u_{ij}^{t} - u_{ij-1}^{t}) \\
& + \frac{1}{(\Delta z_2)_{j+1}} (w_{ij+1}^{t} + w_{i-1j+1}^{t})(u_{ij+1}^{t} - u_{ij}^{t}) \Bigg] \\
& + v_{ij}^{t} \left[\frac{v_{ij}^{t}}{(r_1)_{i}} + f \right] \\
& + K_H \Bigg\{ \frac{1}{(\Delta r_2)_{i}} \Bigg[\frac{1}{(\Delta r_1)_{i}} (u_{i+1j}^{t-\Delta t} - u_{ij}^{t-\Delta t}) \\
& - \frac{1}{(\Delta r_1)_{i-1}} (u_{ij}^{t-\Delta t} - u_{i-1j}^{t-\Delta t}) \Bigg] \\
& + 0.5 \Bigg[\frac{1}{(r_2)_{i} (\Delta r_1)_{i}} (u_{i+1j}^{t-\Delta t} - u_{ij}^{t-\Delta t}) \\
& + \frac{1}{(r_2)_{i-1} (\Delta r_1)_{i-1}} (u_{ij}^{t-\Delta t} - u_{i-1j}^{t-\Delta t}) \Bigg] \\
& - \frac{u_{ij}^{t-\Delta t}}{(r_1)_{i}^{2}} \Bigg\} + \frac{K_z}{(\Delta z_1)_{j}} \Bigg[\frac{1}{(\Delta z_2)_{j+1}} (u_{ij+1}^{t-\Delta t} - u_{ij}^{t-\Delta t}) \\
& - \frac{1}{(\Delta z_2)_{j}} (u_{ij}^{t-\Delta t} - u_{ij-1}^{t-\Delta t}) \Bigg]
\end{aligned}
\tag{3-5}
$$

(b) The Equation of Motion in θ-direction

$$\frac{\partial v_{ij}^t}{\partial t} = -0.25 \left[\frac{1}{(\Delta r_1)_{i-1}} (u_{ij}^t + u_{i-1j}^t)(v_{ij}^t - v_{i-1j}^t) \right.$$

$$+ \frac{1}{(\Delta r_1)_i} (u_{i+1j}^t + u_{ij}^t)(v_{i+1j}^t - v_{ij}^t)$$

$$+ \frac{1}{(\Delta z_2)_j} (w_{i-1j}^t + w_{ij}^t)(v_{ij}^t - v_{ij-1}^t)$$

$$\left. + \frac{1}{(\Delta z_2)_{j+1}} (w_{ij+1}^t + w_{i-1j+1}^t)(v_{ij+1}^t - v_{ij}^t) \right]$$

$$- u_{ij}^t \left[\frac{v_{ij}^t}{(r_1)_i} + f \right]$$

$$+ \frac{K_H}{(\Delta r_2)_i} \left(\left[\frac{1}{(\Delta r_1)_i} (v_{i+1j}^{t-\Delta t} - v_{ij}^{t-\Delta t}) \right. \right.$$

$$\left. - \frac{1}{(\Delta r_1)_{i-1}} (v_{ij}^{t-\Delta t} - v_{i-1j}^{t-\Delta t}) \right]$$

$$+ 0.5 \left[\frac{1}{(r_2)_i (\Delta r_1)_i} (v_{i+1j}^{t-\Delta t} - v_{ij}^{t-\Delta t}) \right.$$

$$\left. + \frac{1}{(r_2)_{i-1} (\Delta r_1)_{i-1}} (v_{ij}^{t-\Delta t} - v_{i-1j}^{t-\Delta t}) \right]$$

$$\left. - \frac{v_{ij}^{t-\Delta t}}{(r_1)_i^2} \right) + \frac{K_z}{(\Delta z_1)_j} \left[\frac{1}{(\Delta z_2)_{j+1}} (v_{ij+1}^{t-\Delta t} - v_{ij}^{t-\Delta t}) \right.$$

$$\left. - \frac{1}{(\Delta z_2)_j} (v_{ij}^{t-\Delta t} - v_{ij-1}^{t-\Delta t}) \right] \qquad (3-4)$$

(c) The Equation of Motion in z-direction

$$\frac{\partial w_{ij}^t}{\partial t} = G_{ij}^t - \frac{1}{\rho_o(\Delta z_2)_j}(p_{ij}-p_{ij-1}) \qquad (3\text{-}5)$$

where

$$G_{ij}^t = -0.25\left[\frac{1}{(\Delta r_2)_i}(u_{ij}^t+u_{ij-1}^t)(w_{ij}^t-w_{i-1j}^t)\right.$$

$$+\frac{1}{(\Delta r_2)_{i+1}}(u_{i+1j}^t+u_{i+1j-1}^t)(w_{i+1j}^t-w_{ij}^t)$$

$$+\frac{1}{(\Delta z_1)_{j-1}}(w_{ij-1}^t+w_{ij}^t)(w_{ij}^t-w_{ij-1}^t)$$

$$\left.+\frac{1}{(\Delta z_1)_j}(w_{ij+1}^t+w_{ij}^t)(w_{ij+1}^t-w_{ij}^t)\right]$$

$$-0.5(b_{ij}^t+b_{ij-1}^t)$$

$$+K_H\left\{\frac{1}{(\Delta r_1)_i}\left[\frac{1}{(\Delta r_2)_{i+1}}(w_{i+1j}^{t-\Delta t}-w_{ij}^{t-\Delta t})\right.\right.$$

$$\left.-\frac{1}{(\Delta r_2)_i}(w_{ij}^{t-\Delta t}-w_{i-1j}^{t-\Delta t})\right]$$

$$+0.5\left[\frac{1}{(r_1)_{i+1}(\Delta r_2)_{i+1}}(w_{i+1j}^{t-\Delta t}-w_{ij}^{t-\Delta t})\right.$$

$$\left.\left.+\frac{1}{(r_1)_i(\Delta r_2)_i}(w_{ij}^{t-\Delta t}-w_{i-1j}^{t-\Delta t})\right]\right\}$$

$$+ \frac{K_z}{(\Delta z_2)_j}\left[\frac{1}{(\Delta z_1)_j}(w_{ij+1}^{t-\Delta t}-w_{ij}^{t-\Delta t}) - \frac{1}{(\Delta z_1)_{j-1}}(w_{ij}^{t-\Delta t}-w_{ij-1}^{t-\Delta t})\right] \quad (3\text{-}6)$$

(d) The Thermodynamic Equation

$$\frac{\partial b_{ij}^t}{\partial t} = -0.5\left[\frac{u_{ij}^t}{(\Delta r_2)_i}(b_{ij}^t-b_{i-1j}^t) + \frac{u_{i+1j}^t}{(\Delta r_2)_{i+1}}(b_{i+1j}^t-b_{ij}^t)\right.$$

$$\left. + \frac{w_{ij}^t}{(\Delta z_2)_j}(b_{ij}^t-b_{ij-1}^t) + \frac{w_{ij+1}}{(\Delta z_2)_{j+1}}(b_{ij+1}^t-b_{ij}^t)\right]$$

$$+ 0.5\ (w_{ij+1}^t+w_{ij}^t)\ N_z^2$$

$$+ K_H\left\{\frac{1}{(\Delta r_1)_i}\left[\frac{1}{(\Delta r_2)_{i+1}}(b_{i+1j}^{t-\Delta t}-b_{ij}^{t-\Delta t})\right.\right.$$

$$\left. - \frac{1}{(\Delta r_2)_i}(b_{ij}^{t-\Delta t}-b_{i-1j}^{t-\Delta t})\right]$$

$$+ 0.5\left[\frac{1}{(r_1)_{i+1}(\Delta r_2)_{i+1}}(b_{i+1j}^{t-\Delta t}-b_{ij}^{t-\Delta t})\right.$$

$$\left.\left. + \frac{1}{(r_1)_i(\Delta r_2)_i}(b_{ij}^{t-\Delta t}-b_{i-1j}^{t-\Delta t})\right]\right\}$$

$$+ \frac{K_z}{(\Delta z_1)_j}\left[\frac{1}{(\Delta z_2)_{j+1}}(b_{ij+1}^{t-\Delta t}-b_{ij}^{t-\Delta t})\right.$$

$$\left. - \frac{1}{(\Delta z_2)_j}(b_{ij}^{t-\Delta t}-b_{ij-1}^{t-\Delta t})\right] \quad (3\text{-}7)$$

4. DERIVATION OF THE DIAGNOSTIC EQUATION FOR PRESSURE

The nonhydrostatic pressure at time t is needed to compute the pressure gradient forces in (3-2) and (3-5). To "recover" the pressure from the motion fields, we make use of the continuity equation by differentiating (1-7) with time we get

$$\frac{1}{r}\frac{\partial}{\partial r} r \frac{\partial u}{\partial t} + \frac{\partial}{\partial z}\frac{\partial w}{\partial t} = 0 \ ,$$

which can be written in finite difference form for a mass point ij as

$$\frac{1}{\frac{1}{2}\left[(r_1)_i + (r_1)_{i+1}\right](\Delta r_1)_i}\left[(r_1)_{i+1}\frac{\partial u^t_{i+1,j}}{\partial t} - (r_1)_i\frac{\partial u^t_{ij}}{\partial t}\right]$$

$$+ \frac{1}{(\Delta z_1)_j}\left[\frac{\partial w^t_{i,j+1}}{\partial t} - \frac{\partial w^t_{ij}}{\partial t}\right] = 0 \qquad (4\text{-}1)$$

Let $$c_i = (r_1)_{i+1}\Big/\left\{\frac{1}{2}\left[(r_1)_i + (r_1)_{i+1}\right](\Delta r_1)_i\right\}, \qquad (4\text{-}2)$$

and $$a_i = (r_1)_i\Big/\left\{\frac{1}{2}\left[(r_1)_i + (r_1)_{i+1}\right](\Delta r_1)_i\right\}$$

Substituting (3-2), (3-5) and (4-2) into (4-1), we have

$$c_i H^t_{i+1j} - \frac{1}{\varepsilon_o}\frac{c_i}{(\Delta r_2)_{i+1}}(p_{i+1j}-p_{ij}) - a_i H^t_{ij}$$

$$+ \frac{1}{\varepsilon_o}\frac{a_i}{(\Delta r_2)_i}(p_{ij}-p_{i-1j}) + \frac{1}{(\Delta z_1)_j} G^t_{ij+1} - \frac{1}{(\Delta z_1)_j} G^t_{ij}$$

$$- \frac{1}{\varepsilon_o(\Delta z_1)_j(\Delta z_2)_{j+1}} (p_{ij+1} - p_{ij})$$

$$+ \frac{1}{\varepsilon_o(\Delta z_1)_j(\Delta z_2)_j} (p_{ij}-p_{ij-1}) = 0$$

After some rearrangements, we get

$$- \frac{c_i}{(\Delta r_2)_{i+1}} p_{i+1j} - \frac{a_i}{(\Delta r_2)_i} p_{i-1j}$$

$$- \frac{1}{(\Delta z_1)_j(\Delta z_2)_j} p_{ij-1} - \frac{1}{(\Delta z_1)_j(\Delta z_2)_{j+1}} p_{ij+1}$$

$$+ \left[\frac{c_i}{(\Delta r_2)_{i+1}} + \frac{a_i}{(\Delta r_2)_i} + \frac{1}{(\Delta z_1)_j(\Delta z_2)_{j+1}} + \frac{1}{(\Delta z_1)_j(\Delta z_2)_j}\right] p_{ij}$$

$$= \varepsilon_o\left[- c_i H^t_{i+1j} + a_i H^t_{ij} - \frac{1}{(\Delta z_1)_j} G^t_{ij+1} + \frac{1}{(\Delta z_1)_j} G^t_{ij}\right] \qquad (4\text{-}3)$$

Now let F_{ij} = RHS of (4-3),

$$CX_i = \frac{c_i}{(\Delta r_2)_{i+1}} = (r_1)_{i+1} \Big/ \left\{ \frac{1}{2}\left[(r_1)_i + (r_1)_{i+1}\right] (\Delta r_1)_i (\Delta r_2)_{i+1} \right\} ,$$

$$AX_i = \frac{a_1}{(\Delta r_2)_i} = (r_1)_i \Big/ \left\{ \frac{1}{2}\left[(r_1)_i + (r_1)_{i+1}\right] (\Delta r_1)_i (\Delta r_2)_i \right\} ,$$

$$C\Xi_j = 1/\left[(\Delta \xi_1)_j (\Delta \xi_2)_{j+1}\right] ,$$

$$A\Xi_j = 1/\left[(\Delta \xi_1)_j (\Delta \xi_2)_j\right] , \text{ and}$$

$$BB_{ij} = - CX_i - AX_i - C\Xi_j - A\Xi_j \qquad (4\text{-}4)$$

We obtain the standard form of an elliptic equation in FD form

$$AX_i P_{i-1j} + A\Xi_j P_{ij-1} + BB_{ij} P_{ij} + CX_i P_{i+1j} + C\Xi_j P_{ij+1} = F_{ij} \qquad (4\text{-}5)$$

Equation (4-5) can be solved numerically by the SEVP solver (Madala, 1978), providing the boundary conditions are properly posed.

The conditions for the four boundaries are determined according to the following assumptions:

(a) At $(r_1)_i = (r_1)_1 = 0$, the natural condition for the cylindrical coordinates calls for $u = v = 0 = \partial u/\partial t = \partial v/\partial t$, the gradient balance requires that $(\partial p/\partial r)_{r=0} = 0$. Therefore an extra column of P is needed

$$P_{oj} = P_{1j} \qquad (4\text{-}6)$$

(b) At $(r_1)_i = (r_1)_m$, assuming both the horizontal divergence and the vorticity are continuous, i.e., $\frac{\partial}{\partial r}\frac{1}{r}\frac{\partial ur}{\partial r} = 0$ and $\frac{\partial}{\partial r}\frac{1}{r}\frac{\partial vr}{\partial r} = 0$. These lead to

$$u_{mj} = b_a u_{m1j} + b_b[(r_1)_{m1}u_{m1j} - (r_1)_{m2}u_{m2j}]$$
$$v_{mj} = b_a v_{m1j} + b_b[(r_1)_{m1}v_{m1j} - (r_1)_{m2}v_{m2j}] \qquad (4\text{-}7)$$

where $b_a = (r_1)_{m1}/(r_1)_m$, and

$$b_b = [(r_1)_{m1}+(r_1)_m](\Delta r_1)_{m1}/\{(\Delta r_1)_{m2}[(r_1)_{m1}+(r_1)_{m2}]\}$$

Note that if b_b is set equal to zero, (4-7) describes a non-divergent and zero-vorticity boundary condition at $r = (r_1)_m$. Once v_{mj} is determined, a gradient balance at $r = (r_1)_m$ requires

$$\rho_o v_{mj}\left[\frac{v_{mj}}{(r_1)_m} + f\right] = \frac{1}{(\Delta r_2)_m}(p_{mj}-p_{m-1j})$$

or

$$p_{mj} = p_{m-1j} + \rho_o(\Delta r_2)_m v_{mj}\left[\frac{v_{mj}}{(r_1)_m} + f\right] \qquad (4\text{-}8)$$

where a column of dummy points p_{mj} has been introduced for computational purposes. The second part of the RHS of (4-8) is thus the forcing function at $(r_1)_m$ for the elliptic equation (4-5).

(c) At the bottom, $w_{i1} = \frac{\partial}{\partial t} w_{i1} = 0$. Substituting these into the continuity equation (4-1), we get

$$\frac{1}{\frac{1}{2}(r_1)_i + (r_i)_{i+1}(\Delta r_1)_i}\left[(r_1)_{i+1}\frac{\partial u^t_{i+1,1}}{\partial t} - (r_1)_i \frac{\partial u^t_{i1}}{\partial t}\right]$$

$$+ \frac{1}{(\Delta z_1)_1}\frac{\partial w^t_{i2}}{\partial t} = 0 \ . \qquad (4\text{-}9)$$

Following the same deduction between (4-1) and (4-5), we get an expression similar to (4-5) with the second team on the LHS and G_{i1} in the RHS absent. Thus, P_{i1} can be obtained by the same SEVP solver by setting $CZ_1 = 0$ and $G_{i1} = 0$.

(d) At top $w_{in} = \partial/\partial t\ w_{in} = 0$. Following the same line of reasoning as in (c), we obtain P_{in} by solving (4-5) with $CZ_n\ P_{in+1} = 0$ and $G_{in} = 0$.

In summary, the elliptic pressure diagnostic equation (4-4) is to be solved with the following boundary conditions

1) At $r = 0$ $\quad P_{oj} = P_{1j}$ i.e., (4-6)

2) At $r = (r_1)_m$ $\quad P_{mj} = P_{m-1j} + \text{function}\ (v_{mj})$ (4-8)

3) At $z = 0$ $\quad CZ_1 = 0$ and $G_{i1} = 0$

4) At $z = (z_1)_n$ $\quad CZ_n = 0$ and $G_{in} = 0$

LIST OF SYMBOLS

AX_i an array of constants, varying only in r-direction, defined by (4-4), used in (4-5)

AZ_j an array of constants, varying only in z-direction defined by (4-4), used in (4-5)

a_i an array of constants related to r_1 and Δr_1 used in (4-2)

BB_{ij} an array of constants, used in (4-5)

b density anomalies, defined in (1-5), cm s^{-2}

CX_i an array of constants, varying only in r-direction, defined by (4-4), used in (4-5)

CZ_j an array of constants, varying only in z-direction, defined by (4-4), used in (4-5)

c_i an array of constants, related to r_1 and Δr_1, used in (4-5)

f Coriolis parameter, s^{-1}

g gravitational acceleration, cm s^{-2}

i an index, denoting i-th point in r-direction

j an index, denoting j-th point in z-direction

K_H horizontal diffusion coefficient, cm^2 s^{-1}

K_z vertical diffusion coefficient, cm^2 s^{-1}

LHS left hand side

m the maximum number of grid points in r-direction, upper bound of i

m_1	m-1
m_2	m-2
N_2	Brunt-Väisällä frequency, s^{-1}
n	the maximum number of grid points in z-direction, upper bound of j
n_1	n-1
n_2	n-2
p	pressure, dyne cm^{-2}
RHS	right hand side
r	radius, cm
r_1	radii of momentum points, cm
r_2	radii of mass points, cm
Δr_1	distance between two horizontally adjacent momentum points, cm
Δr_2	distance between two horizontally adjacent mass points, cm
SEVP	stabilized error vector propagation
t	time, s
Δt	time interval, s
u	radial velocity, cm s^{-1}
v	tangential velocity, cm s^{-1}
w	vertical velocity, cm s^{-1}
z	height from ocean bottom, cm
z_1	heights of circle points, cm
z_2	heights of cross and dot points, cm

Δz_1 distance between two vertically adjacent circle points, cm

Δz_2 distance between two vertically adjacent cross or dot points

ρ density, g cm^{-3}

ρ_o a constant density, 1 g cm^{-3}

ρ_r a reference density, varying only in z-direction, g cm^{-3}

ACKNOWLEDGMENTS

Discussions with Dr. R. V. Madala on the SEVP solver and the skillful typing of Mrs. Doris Beechum and Mrs. Judy Staudinger are greatly appreciated.

REFERENCE

Madala, R. V., 1978: An Efficient Direct Solver for Separable and Non-Separable Elliptic Equations. Month Weather Review, 106, 1735-1741.

APPENDIX A — FORTRAN CODE FOR THE NON—HYDROSTATIC MODEL

A listing of FORTRAN code of the ocean model. The major functions of the main program and subroutines are as follows:

OCEAN	main program, calls all subroutines, manages job flow, controls input/output.
INIT	sets up independent variables, defines constants
START	defines initial conditions
PUTOUT	gets various fields ready for output
MAP	prints
ADVECT	computes all inviscous terms, except for the pressure gradient forces
DIFF	computes horizontal and vertical diffusions
PRESS	solves the pressure diagnostic equations and computes the pressure gradient forces, appears only in the non-hydrostatic version
MATINV	inverts matrices
BSM1	Used in SEVP method
BSM2	
BSM3	
FRWRD	matches forward
BOUNDV	sets outer boundary conditions for momentum
CHECK	checks if the time step is linearly stable.

APPENDIX B — FORTRAN CODE FOR THE HYDROSTATIC MODEL

The hydrostatic version of the model can be obtained by simplifying the non-hydrostatic version. In the hydrostatic version, the equation of motion in z-direction (1-5) is reduced to the hydrostatic equation

$$-\frac{1}{\rho_0}\frac{\partial p}{\partial z} = b \tag{B-1}$$

Instead of solving the elliptic equation (4-5), the pressure p is thus obtainable by vertically integrating (B-1). The vertical velocity w can also be computed by vertically integrating the continuity equation (1-7).

The FD forms of (B-1) and (1-7) are, respectively,

$$p_{ij} = p_{ij-1} - 0.5\,\rho_0(\Delta z_r)_j\,(B^t_{ij} + B^t_{ij-1}) \tag{B-2}$$

$$w_{ij} = w_{ij} + \frac{\left|(r_1)_{i+1}\,u^t_{i+1j-1} - (r_1)_i\,u^t_{ij-1}\right|(\Delta z_1)_j}{0.5\,(\Delta r_1)_i\,\left|(r_1)_{i+1} + (r_1)_i\right|} \tag{B-3}$$

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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

<<$PLIT OCEAN0,SOLRC0,PRINT,SEG

      1*       PROGRAM OCEAN                                                  0001000
      2*       PARAMETER M=21,N=21                                            0002000
      3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                          0003000
      4*       PARAMETER ND=2*M*N+M1*N+M*N1                                   0004000
      5*       DIMENSION DATA1(ND),DATA2(ND),DATA3(ND)                        0005000
      6*       COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),B1(M1,N1),VR2(M,N1),  0006000
      7*      1          VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),   0007000
      8*      2          VZ3(M1,N),B3(M1,N1),P(M1,N1)                         0008000
      9*       EQUIVALENCE (DATA1,VR1),(DATA2,VR2),(DATA3,VR3)                0009000
     10*       DATA DATA1/ND*0./,DATA2/ND*0./,DATA3/ND*0./                    0010000
     11*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N) 0011000
     12*       COMMON/THR/RHR,RHRR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N) 0012000
     13*       COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMO,ITAPE,TBV               0013000
     14*       CALL INDUMP                                                    0014000
     15*   100 FORMAT(I4)                                                     0015000
     16*       READ(5,100)ITIME                                               0016000
     17*       READ(5,100)ITER                                                0017000
     18*       READ(5,100)IOUT                                                0018000
     19*       READ(5,100)ISMO                                                0019000
     20*       ISTEP=0                                                        0020000
     21*       READ(5,100)ITAPE                                               0021000
     22*       CALL INIT                                                      0022000
     23*       IF(ITIME.EQ.0)GO TO 10                                         0023000
     24* C                                                                    0024000
     25* C                     CONTINUED INTEGRATION FROM A HISTORY TAPE      0025000
     26* C                                                                    0026000
     27*       READ(1)ITIME,DATA1,DATA2,P                                     0027000
     28*       GO TO 20                                                       0028000
     29*    10 CALL START                                                     0029000
     30*    20 XTIME=ITIME+3600.                                              0030000
     31* C                                                                    0031000
     32* C                     PRINT OUT INITIAL FIELDS                       0032000
     33* C                                                                    0033000
     34*       CALL PUTOUT                                                    0034000
     35*       IF(ITER.EQ.0)STOP                                              0035000
     36*       DO 90 ISTEP=1,ITER                                             0036000
     37* C                                                                    0037000
     38* C                  COMPUTE ALL INVISCID TERMS                        0038000
     39* C                                                                    0039000
     40*       CALL ADVECT                                                    0040000
     41* C                                                                    0041000
     42* C                     COMPUTE VISCOUS TERMS                          0042000
     43* C                                                                    0043000
     44*       CALL DIFF                                                      0044000
     45* C                                                                    0045000
     46* C                     ADD ADD PRESSURE GRADIENT FORCES TO TENDENCIES  0046000
     47* C                     DIAGNOSE (RECOVER) THE PRESSURE FIELD          0047000
     48* C                                                                    0048000
     49*       CALL PRESS                                                     0049000
     50* C                                                                    0050000
     51* C                     MARCHING IN TIME                               0051000
     52* C                     FIRST TIME STEP IS FORWARD IF START IS CALLED  0052000
     53* C                                                                    0053000
     54*       IF(ISTEP.EQ.1.AND.ITIME.EQ.0)DELT=0.5*DELT                     0054000
     55*       CALL FRWRD                                                     0055000
     56*       IF(ISTEP.EQ.1.AND.ITIME.EQ.0)DELT=2.*DELT                      0056000
     57* C                                                                    0057000
     58* C                     DEFINE BOUNDARY VALUES FOR VELOCITY            0058000
     59* C                                                                    0059000
     60*       CALL BOUNDV                                                    0060000
     61* C                                                                    0061000
     62* C                     CHECK IF DELT IS STABLE                        0062000
     63* CC                                                                   0063000
     64*       CALL CHECK                                                     0064000
     65*       XTIME=XTIME+DELT                                               0065000
     66*       ITIME=XTIME/3600.                                              0066000
     67* C                                                                    0067000
     68* C                     PRINT OUT RESULTS EVERY IOUT STEPS             0068000
     69* C                                                                    0069000
     70*       IF(MOD(ISTEP,IOUT).EQ.0)CALL PUTOUT                            0070000
     71* C                                                                    0071000
     72* C                     WRITE HISTORY TAPE EVERY ITAPE STEPS           0072000
     73* C                                                                    0073000
     74*       IF(MOD(ISTEP,ITAPE).EQ.0)WRITE(2)ITIME,DATA1,DATA2,P           0074000
     75*    90 CONTINUE                                                       0075000
     76*       STOP                                                           0076000
     77*       END                                                            0077000
```

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CARD IMAGE FILE EDITOR(CIFEH) -- VERSION 05.29  DATE=10/26/82       TIME=14812:12:99

*** MEMBER INIT

  1*        SUBROUTINE  INIT                                                      0001000
  2*        PARAMETER M=21,N=21                                                   0002000
  3*        PARAMETER M1=M+1,M2=M-2,N1=N+1,N2=N-2                                 0003000
  4*        COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),B1(M1,N1),VR2(M,N1),         0004000
  5*       1           VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),       0005000
  6*       2           VZ3(M1,N),B3(M1,N1),P(M1,N1)                             0006000
  7*        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)    0007000
  8*        COMMON/THR/RHO,EMGR(N1),BV2(N),ALPHA,BNDA,BNDR,CORI,G,MK(M),ZK(N)     0008000
  9*        COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMO,ITAPE,TBV                      0009000
 10*        PARAMETER MP=M+1,NP=N+1                                               0010000
 11*        PARAMETER NBLK=2,NBLK1=NBLK-1                                         0011000
 12*        PARAMETER MP1=MP-1,MP2=MP-2,NP1=NP-1,NP2=NP-2                         0012000
 13*        REAL*8 RCOR,RINV,RINV1,RTILDA                                         0013000
 14*        COMMON/EVP/RINV(MP2,MP2,NBLK),RINV1(MP2,MP2,NBLK1),RCOR(MP,3),       0014000
 15*       1           RTILDA(MP2),F(MP,NP),NBSIZ2(NBLK),IS(NBLK),SLMF(NBLK),    0015000
 16*       2           IE(NBLK),F11(MP),F1N(MP),F21(NP),F2M(NP),AX(MP),AY(NP),   0016000
 17*       3           BB(MP,NP),CX(MP),CY(NP)                                   0017000
 18* C                                                                           0018000
 19* C                    INITIALIZE ALL DEPENDENT VARIABLES AND CONSTANTS        0019000
 20* C                                                                           0020000
 21* C                                                                           0021000
 22* C                     ALPHA IS THE NONDIMENSIONAL SMOOTHING COEF.           0022000
 23* C                     FOR TIME SMOOTHING IN SUBROUTINE FWRD                 0023000
 24* C                                                                           0024000
 25*        DELT=900.                                                            0025000
 26*        ALPHA=0.10                                                           0026000
 27*        G=980.                                                               0027000
 28*        LAT=30                                                               0028000
 29*        CORI=2.*7.2722E-5*SIN(LAT*3.14159/180.)                              0029000
 30* C                                                                           0030000
 31* C                    DEFINE RADII AT GRID POINTS AND ALL GRID INTERVALS     0031000
 32* C                                                                           0032000
 33*        DO 10 I=1,M1                                                         0033000
 34*     10 DR1(I)=20.ES                                                         0034000
 35*        R1(1)=0.                                                             0035000
 36*        DO 20 I=2,M                                                          0036000
 37*     20 R1(I)=R1(I-1)+DR1(I-1)                                               0037000
 38*        DO 30 I=1,M1                                                         0038000
 39*     30 R2(I)=0.5*(R1(I)+R1(I+1))                                            0039000
 40*        DR2(1)=2.*(R2(1)-R1(1))                                              0040000
 41*        DR2(M)=2.*(R1(M)-R2(M1))                                             0041000
 42*        DO 40 I=2,M1                                                         0042000
 43*     40 DR2(I)=R2(I)-R2(I-1)                                                 0043000
 44* C      MAX=MAXMAG(DR1)                                                      0044000
 45* C      DRMAX=DR1(MAX)                                                       0045000
 46* C                                                                           0046000
 47* C                    DEFINE ALL DZ'S                                        0047000
 48* C                                                                           0048000
 49*        DO 100 J=1,N                                                         0049000
 50*    100 Z1(J)=(J-1)*200.E2                                                   0050000
 51*        DO 110 J=1,N1                                                        0051000
 52*    110 DZ1(J)=Z1(J+1)-Z1(J)                                                 0052000
 53*        DZ2(1)=2.*(0.5*(Z1(1)-Z1(1)))                                        0053000
 54*        Z2(1)=0.5*DZ2(1)                                                     0054000
 55*        DO 120 J=2,N1                                                        0055000
 56*        DZ2(J)=0.5*(DZ1(J)+DZ1(J-1))                                         0056000
 57*    120 Z2(J)=Z2(J-1)+DZ2(J)                                                 0057000
 58*        DZ2(N)=2.*(Z1(N)-Z1(N-1)-0.5*DZ1(N1))                                0058000
 59* C      MAX=MAXMAG(DZ1)                                                      0059000
 60* C      DZMAX=DZ1(MAX)                                                       0060000
 61* C                                                                           0061000
 62* C                    DEFINE CONSTANTS FOR SEVP SOLVER                       0062000
 63* C                                                                           0063000
 64*        AX(1)=0.                                                             0064000
 65*        CX(MP)=0.                                                            0065000
 66*        AY(1)=0.                                                             0066000
 67*        CY(NP)=0.                                                            0067000
 68*        DO 50 I=1,M1                                                         0068000
 69*        AX(I+1)=R1(I)/(0.5*(R1(I)+R1(I+1))*DR1(I)*DR2(I))                    0069000
 70*     50 CX(I+1)=R1(I+1)/(0.5*(R1(I)+R1(I+1))*DR1(I:  :(I+1))                 0070000
 71*        DO 60 J=1,N1                                                         0071000
 72*        AY(J+1)=1./(DZ1(J)*DZ2(J))                                           0072000
 73*     60 CY(J+1)=1./(DZ1(J)*DZ2(J+1))                                         0073000
 74*        DO 70 J=1,NP                                                         0074000
 75*        DO 70 I=1,MP                                                         0075000
 76*     70 BB(I,J)=CX(I)+AX(I)+CY(J)+AY(J)                                      0076000
 77*        NSIZE=N1/NBLK*MRO(N1,2)                                              0077000
 78*        DO 80 NB=1,NBLK1                                                     0078000
 79*     80 NBSIZ2(NB)=NSIZE                                                     0079000
 80*        NBSIZ2(NBLK)=N1-(NBLK-1)*NSIZE*NBLK1
```

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*** MEMBER INIT
                                                                                0080000
      81* C                                                                     0081000
      82* C                     A AND B ARE CONSTANT USED IN SUBROUTINE BOUNDV   0082000
      83* C                     FOR CONSTANT DIV, AND VORT, CONDITIONS          0083000
      84* C                                                                     0084000
      85*       BNDA=R1(M1)/R1(M)                                               0085000
      86*       BNDB=(R1(M1)*R1(M))*DR1(M1)/((R1(M1)*R1(M2))*R1(M)*DR1(M2))     0086000
      87*       BNDB=0.                                                         0087000
      88* C                                                                     0088000
      89* C                     DEFINE DENSITY RELATED CONSTANTS                0089000
      90* C                                                                     0090000
      91*       RM=R1.                                                          0091000
      92*       DO 130 J=1,N                                                    0092000
      93*  130  RV2(J)=1.E-6                                                    0093000
      94*       TRV=0.                                                          0094000
      95*       DO 135 J=1,N                                                    0095000
      96*  135  TRV=AMAX1(TRV,RV2(J))                                           0096000
      97*       TRV=1./SQRT(TRV)                                                0097000
      98* C                                                                     0098000
      99* C                     DEFINE HORIZONTAL AND VERTICAL DIFFUSION COEFFIENTS 0099000
     100* C                                                                     0100000
     101*       COEFH=0.002*DR(1)**2/DELT                                       0101000
     102*       COEFZ=0.001*DZ1(1)**2/DELT                                      0102000
     103*       DO 140 I=1,M1                                                   0103000
     104*  140  HK(I)=COEFH*(1.+.5*EXP(-FLOAT(M1-I)/7.))                        0104000
     105*       DO 150 J=1,N1                                                   0105000
     106*  150  ZK(J)=COEFZ*(1.+.5*(EXP(-FLOAT(J-1)/5.)+EXP(-FLOAT(N1-J)/5.))) 0106000
     107*       RETURN                                                          0107000
     108*       END                                                             0108000
```

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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER START

      1*       SUBROUTINE START                                                       0001000
      2*       PARAMETER M=21,N=21                                                    0002000
      3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                  0003000
      4*       COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),R1(M1,N1),VR2(M,N1),          0004000
      5*      1           VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),        0005000
      6*      2           VZ3(M1,N),R3(M1,N1),P(M1,N1)                               0006000
      7*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)     0007000
      8*       COMMON/THR/RHO,PHI(N1),RV2(N),ALPHA,BNDA,BNDB,C9RI,G,HK(M),ZK(N)       0008000
      9*       PARAMETER NC=2*M*N1+M1*N+M1*N1                                         0009000
     10*       DIMENSION DATA1(NC),DATA2(ND)                                          0010000
     11*       EQUIVALENCE (DATA1,VR1),(DATA2,VR2)                                    0011000
     12* C                                                                            0012000
     13* C                      INITIALIZE MASS FIELDS FOR A THEORETICAL RING          0013000
     14* C                                                                            0014000
     15*       I11=1                                                                  0015000
     16*       I12=13                                                                 0016000
     17*       I21=I12+1                                                              0017000
     18*       I22=M1                                                                 0018000
     19*       RMAG=0.0002                                                            0019000
     20*       DO 10 I=I11,I12                                                        0020000
     21*    10 R1(I,N1)=RMAG*COS(FLOAT(I-I11)/A.*3.14159)*G/RHO                       0021000
     22*       DO 30 I=I21,I22                                                        0022000
     23*    30 R1(I,N1)=R1(I12,N1)*EXP(-FLOAT(I-I21+1)/4.)                            0023000
     24*       DO 40 J=1,N2                                                           0024000
     25*       FACT=EXP(FLOAT(J-N1)/5.)                                               0025000
     26*       DO 40 I=1,M1                                                           0026000
     27*    40 R1(I,J)=R1(I,N1)*FACT                                                  0027000
     28* C                                                                            0028000
     29* C                      PRESSURE IS OBTAINED HYDROSTATICALLY FROM BUOYANCY     0029000
     30* C                                                                            0030000
     31*       DO 50 I=1,M1                                                           0031000
     32*    50 P(I,1)=0.5*RHO*DZ2(1)*R1(I,1)                                          0032000
     33*       DO 60 J=2,N1                                                           0033000
     34*       DO 60 I=1,M1                                                           0034000
     35*    60 P(I,J)=P(I,J-1)+0.5*RHO*DZ2(J)*(R1(I,J)+R1(I,J-1))                     0035000
     36* C                                                                            0036000
     37* C                      TANGENTIAL VELOCITY IS IN GRADIENT BALANCE WITH MASS   0037000
     38* C                                                                            0038000
     39*       DO 70 J=1,N1                                                           0039000
     40*       DO 70 I=2,M1                                                           0040000
     41*       PGF=(P(I,J)-P(I-1,J))/(RHO*DR2(I))                                     0041000
     42*       RAD=(0.5*C9RI*R1(I))**2+R1(I)*PGF                                      0042000
     43*       JJ=J                                                                   0043000
     44*       II=I                                                                   0044000
     45*       IF(RAD.LT.0.)GO TO 100                                                 0045000
     46*    70 VT1(I,J)=0.5*C9RI*R1(I)+SQRT(RAD)                                      0046000
     47* C                                                                            0047000
     48* C                      SET DATA2=DATA1 FOR LEAPFROG                          0048000
     49* C                                                                            0049000
     50*       DO 80 I=1,ND                                                           0050000
     51*    80 DATA2(I)=DATA1(I)                                                      0051000
     52*       CALL BALNDV                                                            0052000
     53*       DO 90 I=1,ND                                                           0053000
     54*    90 DATA1(I)=DATA2(I)                                                      0054000
     55*       RETURN                                                                 0055000
     56*   100 PRINT 110,II,JJ,PGF,RAD                                               0056000
     57*   110 FORMAT(' RADICAL IN SUBROUTINE START IS NEGATIVE AT (I,J)=',2I5,      0057000
     58*      1' PGF, RAD =',1P2E12.3)                                               0058000
     59*       STOP                                                                   0059000
     60*       END                                                                    0060000
```

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*** MEMBER HOLNDV

                1*        SUBROUTINE HOLNDV                                                      0001000
                2*        PARAMETER (M2=21,N2=21                                                 0002000
                3*        PARAMETER (M1M=1,M2M=2,N1M=1,N2M=2                                     0003000
                4*        COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),R1(M1,N1),VR2(M,N1),          0004000
                5*       1          VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),          0005000
                6*       2          VZ3(M1,N),B3(M1,N1),P(M1,N1)                                0006000
                7*        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)     0007000
                8*        COMMON/THR/RHO,EMER(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,R*(M),ZK(N)      0008000
                9* C                                                                              0009000
               10* C                    LATERAL BOUNDARY FOR TANGENTIAL AND RADIAL VELOCITIES     0010000
               11* C                    ASSUMING CONTINUOUS VORTICITY AND DIVERGENCE               0011000
               12* C                                                                              0012000
               13*        DO 10 J=1,N1                                                           0013000
               14*        VR2(M,J)=BNDA*VR2(M1,J)+BNDB*(R1(M1)*VR2(M1,J)-R1(M2)*VR2(M2,J))       0014000
               15*     10 VT2(M,J)=BNDA*VT2(M1,J)+BNDB*(R1(M1)*VT2(M1,J)-R1(M2)*VT2(M2,J))       0015000
               16*        RETURN                                                                 0016000
               17*        END                                                                    0017000
```

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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82        TIME=14:12:12:99

*** MEMBER DIFF

      SUBROUTINE DIFF                                                   0001000
C                                                                       0002000
C                     COMPUTE THE DIFFUSION TERMS                       0003000
C                                                                       0004000
      PARAMETER M=21,N=21                                               0005000
      PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                             0006000
      COMMON/CME/VR1(M,N1),VT1(M,N1),VZ1(M1,N),B1(M1,N1),VR2(M,N1),     0007000
     1           VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),     0008000
     2           VZ3(M1,N),B3(M1,N1),P(M1,N1)                           0009000
      COMMON/TMP/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N) 0010000
      COMMON/THR/RHO,RHOR(N1),RHOZ(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N) 0011000
      DIMENSION VR(M,N1),VT(M,N1),VZ(M1,N),B(M1,N1)                     0012000
      EQUIVALENCE (VR,VR1),(VT,VT1),(VZ,VZ1),(B,B1)                     0013000
C                                                                       0014000
C                     HORIZONTAL DIFFUSION OF RADIAL VELOCITY           0015000
C                                                                       0016000
      DO 10 J=1,N1                                                      0017000
      DO 10 I=2,M1                                                      0018000
   10 VR3(I,J)=VR3(I,J)+HK(I)*(((VR(I+1,J)-VR(I,J))/DR1(I)              0019000
     1        -(VR(I,J)-VR(I-1,J))/DR1(I-1))/DR2(I)-VR(I,J)/(R1(I)*R1(I)) 0020000
     2          +0.5*((VR(I+1,J)-VR(I,J))/(DR1(I)*R2(I))                0021000
     3          +(VR(I,J)-VR(I-1,J))/(DR1(I-1)*R2(I-1))))               0022000
C                                                                       0023000
C                     HORIZONTAL DIFFUSION OF TANGENTIAL VELOCITY       0024000
C                                                                       0025000
      DO 20 J=1,N1                                                      0026000
      DO 20 I=2,M1                                                      0027000
   20 VT3(I,J)=VT3(I,J)+HK(I)*(((VT(I+1,J)-VT(I,J))/DR1(I)              0028000
     1        -(VT(I,J)-VT(I-1,J))/DR1(I-1))/DR2(I)-VT(I,J)/(R1(I)*R1(I)) 0029000
     2          +0.5*((VT(I+1,J)-VT(I,J))/(DR1(I)*R2(I))                0030000
     3          +(VT(I,J)-VT(I-1,J))/(DR1(I-1)*R2(I-1))))               0031000
C                                                                       0032000
C                     HORIZONTAL DIFFUSION OF VERTICAL VELOCITY         0033000
C                                                                       0034000
      DO 30 J=2,N1                                                      0035000
      DO 30 I=2,M2                                                      0036000
   30 VZ3(I,J)=VZ3(I,J)+HK(I)*(((VZ(I+1,J)-VZ(I,J))/DR2(I+1)            0037000
     1          -(VZ(I,J)-VZ(I-1,J))/DR2(I))/DR1(I)                     0038000
     2          +0.5*((VZ(I+1,J)-VZ(I,J))/(DR2(I+1)*R1(I+1))           0039000
     3          +(VZ(I,J)-VZ(I-1,J))/(DR2(I)*R1(I))))                   0040000
      DO 40 J=2,N1                                                      0041000
   40 VZ3(1,J)=VZ3(1,J)+HK(1)*((VZ(2,J)-VZ(1,J))/(DR2(1)*DR1(1))        0042000
     1          +0.5*(VZ(2,J)-VZ(1,J))/(DR2(2)*R1(2)))                  0043000
      DO 50 J=2,N1                                                      0044000
   50 VZ3(M1,J)=VZ3(M1,J)+HK(M1)*((-VZ(M1,J)+VZ(M2,J))/(DR2(M1)*DR1(M1)) 0045000
     1          +(-VZ(M1,J)+VZ(M2,J))/(DR2(M1)*R1(M1)))                 0046000
C                                                                       0047000
C                     HORIZONTAL DIFFUSION OF B                         0048000
C                                                                       0049000
      DO 60 J=1,N1                                                      0050000
      DO 60 I=2,M2                                                      0051000
   60 B3(I,J)=B3(I,J)+HK(I)*(((B(I+1,J)-B(I,J))/DR2(I+1)                0052000
     1          -(B(I,J)-B(I-1,J))/DR2(I))/DR1(I)                       0053000
     2          +0.5*((B(I+1,J)-B(I,J))/(DR2(I+1)*R1(I+1))              0054000
     3          +(B(I,J)-B(I-1,J))/(DR2(I)*R1(I))))                     0055000
      DO 70 J=1,N1                                                      0056000
   70 B3(1,J)=B3(1,J)+HK(1)*((B(2,J)-B(1,J))/(DR2(2)*DR1(1))            0057000
     1          +0.5*(B(2,J)-B(1,J))/(DR2(2)*R1(2)))                    0058000
      DO 80 J=1,N1                                                      0059000
   80 B3(M1,J)=B3(M1,J)+HK(M1)*((-B(M1,J)+B(M2,J))/(DR2(M1)*DR1(M1))    0060000
     1          -(B(M1,J)-B(M2,J))/(DR2(M1)*R1(M1)))                    0061000
C                                                                       0062000
C                     VERTICAL DIFFUSION OF RADIAL VELOCITY             0063000
C                                                                       0064000
      DO 90 J=2,N2                                                      0065000
      DO 90 I=2,M1                                                      0066000
   90 VR3(I,J)=VR3(I,J)+ZK(J)*((VR(I,J+1)-VR(I,J))/DZ2(J+1)            0067000
     1          -(VR(I,J)-VR(I,J-1))/DZ2(J))/DZ1(J)                     0068000
      DO 100 I=2,M1                                                     0069000
  100 VR3(I,1)=VR3(I,1)+ZK(1)*(VR(I,2)-VR(I,1))/(DZ2(2)*DZ1(1))         0070000
      DO 110 I=2,M1                                                     0071000
  110 VR3(I,N1)=VR3(I,N1)+ZK(N1)*(-VR(I,N1)+VR(I,N2))/(DZ2(N1)*DZ1(N1)) 0072000
C                                                                       0073000
C                     VERTICAL DIFFUSION OF TANGENTIAL VELOCITY         0074000
C                                                                       0075000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER DIFF

      76*       DO 120 J=2,N2                                                    0076000
      77*       DO 120 I=2,M1                                                    0077000
      78*   120 VT3(I,J)=VT3(I,J)+ZK(J)*((VT(I,J+1)-VT(I,J))/DZ2(J+1)           0078000
      79*      1          -(VT(I,J)-VT(I,J-1))/DZ2(J))/DZ1(J)                   0079000
      80*       DO 130 I=2,M1                                                    0080000
      81*   130 VT3(I,1)=VT3(I,1)+ZK(1)*(VT(I,2)-VT(I,1))/(DZ2(2)*DZ1(1))       0081000
      82*       DO 140 I=2,M1                                                    0082000
      83*   140 VT3(I,N1)=VT3(I,N1)+ZK(N1)*(-VT(I,N1)+VT(I,N2))/(DZ2(N1)*DZ1(N1)) 0083000
      84*                                                                        0084000
      85* C                                                                     0085000
      86* C                    VERTICAL DIFFUSION OF VERTICAL VELOCITY           0086000
      87* C                                                                     0087000
      88*       DO 150 J=2,N1                                                    0088000
      89*       DO 150 I=1,M1                                                    0089000
      90*   150 VZ3(I,J)=VZ3(I,J)+ZK(J)*((VZ(I,J+1)-VZ(I,J))/DZ1(J)             0090000
      91*      1          -(VZ(I,J)-VZ(I,J-1))/DZ1(J-1))/DZ2(J)                 0091000
      92* C                                                                     0092000
      93* C                    VERTICAL DIFFUSION OF B                          0093000
      94* C                                                                     0094000
      95*       DO 160 J=2,N2                                                    0095000
      96*       DO 160 I=1,M1                                                    0096000
      97*   160 B3(I,J)=B3(I,J)+ZK(J)*((B1(I,J+1)-B(I,J))/DZ2(J+1)               0097000
      98*      1          -(B(I,J)-B(I,J-1))/DZ2(J))/DZ1(J)                     0098000
      99*       DO 170 I=1,M1                                                    0099000
     100*   170 B3(I,1)=B3(I,1)+ZK(1)*(B(I,2)-B(I,1))/(DZ2(2)*DZ1(1))           0100000
     101*       DO 180 I=1,M1                                                    0101000
     102*   180 B3(I,N1)=B3(I,N1)+ZK(N1)*(-B(I,N1)+B(I,N2))/(DZ2(N1)*DZ1(N1))   0102000
     103*       RETURN                                                           0103000
     104*       END                                                              0104000
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CARD IMAGE FILE ECITAP(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER FRWRD

                                                                                0001000
      1*        SUBROUTINE FRWRL                                                0002000
      2*        PARAMETER M=21,N=21                                             0003000
      3*        PARAMETER M1=M+1,M2=M+2,N1=N+1,N2=N+2                           0004000
      4*        PARAMETER ND=2*M*N1+M1*N+M1*N1                                  0005000
      5*        COMMON/ONE/DATA1(ND),DATA2(ND),DATA3(ND),P(M1,N1)               0006000
      6*        COMMON/THR/RHO,EMER(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HH(M),ZK(N) 0007000
      7*        COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMO,ITAPE,TBV                0008000
      8* C                                                                      0009000
      9* C                       REPLACE DATA3 WITH THE NEW VALUES               0010000
     10* C                                                                      0011000
     11*        DO 10 I=1,ND                                                    0012000
     12*     10 DATA3(I)=DATA1(I)+2.*DELT*DATA3(I)                              0013000
     13* C                                                                      0014000
     14* C                       TIME SMOOTHING                                  0015000
     15* C                                                                      0016000
     16*        IF(MOD(ISTEP,ISMO).NE.0)GO TO 30                                0017000
     17*        DO 20 I=1,ND                                                    0018000
     18*     20 DATA2(I)=DATA2(I)+(DATA1(I)+DATA3(I)-2.*DATA2(I))*ALPHA         0019000
     19*     30 CONTINUE                                                        0020000
     20* C                                                                      0021000
     21* C                       FORWARD MARCHING                                0022000
     22* C                                                                      0023000
     23*        DO 40 I=1,ND                                                    0024000
     24*     40 DATA1(I)=DATA2(I)                                               0025000
     25*        DO 50 I=1,ND                                                    0026000
     26*     50 DATA2(I)=DATA3(I)                                               0027000
     27* C                                                                      0028000
     28* C                       ZERO OUT DATA3 FOR NEXT STEP                    0029000
     29* C                                                                      0030000
     30*        DO 60 I=1,ND                                                    0031000
     31*     60 DATA3(I)=0.                                                     0032000
     32*        RETURN                                                          0033000
     33*        END
```

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CARD IMAGE FILE EDITOR(CIFED) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER CHECK

                1*       SUBROUTINE CHECK                                                        0001000
                2*       PARAMETER M=21,N=21                                                     0002000
                3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                   0003000
                4*       COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),R1(M1,N1),VR2(M,N1),           0004000
                5*      1           VT2(M,N1),VZ2(M1,N),R2(M1,N1),VR3(M,N1),VT3(M,N1),          0005000
                6*      2           VZ3(M1,N),R3(M1,N1),P(M1,N1)                                0006000
                7*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)      0007000
                8*       COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISHO,ITAPE,TOV                        0008000
                9*       DIMENSION WORK1(M),WORK2(N)                                             0009000
               10*       DO 10 J=1,N1                                                            0010000
               11*       DO 20 I=1,M                                                             0011000
               12*    20 WORK1(I)=DR2(I)/AMAX1(1.,VR2(I,J))                                      0012000
               13*       MIN=MINMAG(WORK1)+1                                                     0013000
               14*       DT=WORK1(MIN)*0.9                                                       0014000
               15*       DT=AMIN1(DT,DELT)                                                       0015000
               16*    10 CONTINUE                                                                0016000
               17*       DO 40 I=1,M1                                                            0017000
               18*       DO 30 J=1,N                                                             0018000
               19*    30 WORK2(J)=DZ2(J)/AMAX1(1.,VZ2(I,J))                                      0019000
               20*       MIN=MINMAG(WORK2)+1                                                     0020000
               21*       DT=WORK2(MIN)*0.9                                                       0021000
               22*       DT=AMIN1(DT,DELT)                                                       0022000
               23*    40 CONTINUE                                                                0023000
               24*       DT=AMIN1(DT,TOV)                                                        0024000
               25*       IF(DT.GE.DELT)RETURN                                                    0025000
               26*       DELT=0.75*DELT                                                          0026000
               27*       PRINT 100,DELT                                                          0027000
               28*   100 FORMAT(//////,'********DELT IS CHANGED TO',1PE11.2,' S*********')      0028000
               29*       RETURN                                                                  0029000
               30*       END                                                                     0030000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER ZILCH

                1*      SUBROUTINE ZILCH(A,N)                                   0001000
                2*      DIMENSION A(N)                                          0002000
                3*      DO 10 I=1,N                                             0003000
                4*   10 A(I)=0.                                                 0004000
                5*      RETURN                                                  0005000
                6*      END                                                     0006000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12.99

*** MEMBER ADVECT

      1A        SUBROUTINE ADVECT                                                     0001000
      2A C                                                                           0002000
      3A C                    COMPUTE THE ADVECTIVE TERMS                           0003000
      4A C                                                                           0004000
      5A        PARAMETER M=21,N=21                                                  0005000
      6A        PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                0006000
      7A        COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),B1(M1,N1),VR2(M,N1),        0007000
      8A       1           VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),       0008000
      9A       2           VZ3(M1,N),B3(M1,N1),P(M1,N1)                             0009000
     10A        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)  0010000
     11A        COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N)   0011000
     12A        DIMENSION VR(M,N1),VT(M,N1),VZ(M1,N),B(M1,N1)                       0012000
     13A        EQUIVALENCE (VR,VR2),(VT,VT2),(VZ,VZ2),(B,B2)                       0013000
     14A C                                                                          0014000
     15A C                    HORIZONTAL ADVECTION FOR RADIAL VELOCITY              0015000
     16A C                                                                          0016000
     17A        DO 10 J=1,N1                                                        0017000
     18A        DO 10 I=2,M1                                                        0018000
     19A     10 VR3(I,J)=-0.25*((VR(I,J)+VR(I-1,J))*(VR(I,J)-VR(I-1,J))/DR1(I-1)    0019000
     20A       1          +(VR(I+1,J)+VR(I,J))*(VR(I+1,J)-VR(I,J))/DR1(I))          0020000
     21A       2          +VR3(I,J)                                                 0021000
     22A C                                                                          0022000
     23A C                    HORIZONTAL ADVECTION FOR TANGENTIAL VELOCITY          0023000
     24A C                                                                          0024000
     25A        DO 20 J=1,N1                                                        0025000
     26A        DO 20 I=2,M1                                                        0026000
     27A     20 VT3(I,J)=-0.25*((VR(I,J)+VR(I-1,J))*(VT(I,J)-VT(I-1,J))/DR1(I-1)    0027000
     28A       1          +(VR(I+1,J)+VR(I,J))*(VT(I+1,J)-VT(I,J))/DR1(I))          0028000
     29A       2          +VT3(I,J)                                                 0029000
     30A C                                                                          0030000
     31A C                    HORIZONTAL ADVECTION FOR VERTICAL VELOCITY            0031000
     32A C                                                                          0032000
     33A        DO 30 J=2,N1                                                        0033000
     34A        DO 30 I=2,M2                                                        0034000
     35A     30 VZ3(I,J)=-0.25*((VR(I,J)+VR(I,J-1))*(VZ(I,J)-VZ(I-1,J))/DR2(I)      0035000
     36A       1          +(VR(I+1,J)+VR(I+1,J-1))*(VZ(I+1,J)-VZ(I,J))/DR2(I+1))    0036000
     37A       2          +VZ3(I,J)                                                 0037000
     38A        DO 40 J=2,N1                                                        0038000
     39A     40 VZ3(1,J)=-0.25*(VR(2,J)+VR(2,J-1))*(VZ(2,J)-VZ(1,J))/DR2(2)         0039000
     40A       1          +VZ3(1,J)                                                 0040000
     41A        DO 50 J=2,N1                                                        0041000
     42A     50 VZ3(M1,J)=-0.25*(VR(M1,J)+VR(M1,J-1))*(VZ(M1,J)-VZ(M2,J))/DR2(M1)   0042000
     43A       1          +VZ3(M1,J)                                                0043000
     44A C                                                                          0044000
     45A C                    HORIZONTAL ADVECTION FOR BUOYANCY                     0045000
     46A C                                                                          0046000
     47A        DO 60 J=1,N1                                                        0047000
     48A        DO 60 I=2,M2                                                        0048000
     49A     60 B3(I,J)=B3(I,J)-0.5*(VR(I,J)*(B(I,J)-B(I-1,J))/DR2(I)               0049000
     50A       1          +VR(I+1,J)*(B(I+1,J)-B(I,J))/DR2(I+1))                    0050000
     51A        DO 70 J=1,N1                                                        0051000
     52A     70 B3(1,J)=B3(1,J)-0.5*VR(2,J)*(B(2,J)-B(1,J))/DR2(2)                  0052000
     53A        DO 80 J=1,N1                                                        0053000
     54A     80 B3(M1,J)=B3(M1,J)-0.5*VR(M1,J)*(B(M1,J)-B(M2,J))/DR2(M1)            0054000
     55A C                                                                          0055000
     56A C                    VERTICAL ADVECTION FOR RADIAL VELOCITY                0056000
     57A C                                                                          0057000
     58A        DO 90 J=2,N2                                                        0058000
     59A        DO 90 I=2,M1                                                        0059000
     60A     90 VR3(I,J)=VR3(I,J)-0.25*((VZ(I-1,J)+VZ(I,J))*(VR(I,J)-VR(I,J-1))    0060000
     61A       1          /DZ2(J)+(VZ(I,J+1)+VZ(I-1,J+1))*(VR(I,J+1)-VR(I,J))      0061000
     62A       2          /DZ2(J+1))                                                0062000
     63A        DO 95 I=2,M1                                                        0063000
     64A     95 VR3(I,1)=VR3(I,1)-0.25*(VZ(I,2)+VZ(I-1,2))*(VR(I,2)-VR(I,1))        0064000
     65A       1          /DZ2(2)                                                   0065000
     66A        DO 96 I=2,M1                                                        0066000
     67A     96 VR3(I,N1)=VR3(I,N1)-0.25*(VZ(I-1,N1)+VZ(I,N1))*(VR(I,N1)-VR(I,N2)) 0067000
     68A       1          /DZ2(N1)                                                  0068000
     69A C                                                                          0069000
     70A C                    VERTICAL ADVECTION FOR TANGENTIAL VELOCITY            0070000
     71A C                                                                          0071000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER ADVECT

            72*       DO 100 J=2,M2                                                          0072000
            73*       DO 100 I=2,M1                                                          0073000
            74*   100 VT3(I,J)=VT3(I,J)+0.25*((VZ(I-1,J)+VZ(I,J))*(VT(I,J)-VT(I,J-1))       0074000
            75*      1          /DZ2(J)+(VZ(I,J+1)+VZ(I-1,J+1))*(VT(I,J+1)-VT(I,J))        0075000
            76*      2          /DZ2(J+1))                                                  0076000
            77*       DO 105 I=2,M1                                                          0077000
            78*   105 VT3(I,1)=VT3(I,1)+0.25*(VZ(I,2)+VZ(I-1,2))*(VT(I,2)-VT(I,1))           0078000
            79*      1          /DZ2(2)                                                     0079000
            80*       DO 106 I=2,M1                                                          0080000
            81*   106 VT3(I,M1)=VT3(I,M1)-0.25*(VZ(I,M1)+VZ(I-1,M1))*(VT(I,M1)-VT(I,M2))  0081000
            82*      1          /DZ2(M1)                                                    0082000
            83* C                                                                           0083000
            84* C                    VERTICAL ADVECTION FOR VERTICAL VELOCITY               0084000
            85* C                                                                           0085000
            86*       DO 140 J=2,M1                                                          0086000
            87*       DO 140 I=1,M1                                                          0087000
            88*   140 VZ3(I,J)=VZ3(I,J)-0.25*((VZ(I,J-1)+VZ(I,J))*(VZ(I,J)-VZ(I,J-1))       0088000
            89*      1          /DZ1(J-1)+(VZ(I,J+1)+VZ(I,J))*(VZ(I,J+1)-VZ(I,J))          0089000
            90*      2          /DZ1(J))                                                    0090000
            91* C                                                                           0091000
            92* C                    VERTICAL ADVECTION FOR R                               0092000
            93* C                                                                           0093000
            94*       DO 150 J=2,M2                                                          0094000
            95*       DO 150 I=1,M1                                                          0095000
            96*   150 R3(I,J)=R3(I,J)-0.5*(VZ(I,J)*(R(I,J)-R(I,J-1))/DZ2(J)                 0096000
            97*      1          +VZ(I,J+1)*(R(I,J+1)-R(I,J))/DZ2(J+1))                     0097000
            98*       DO 160 I=1,M1                                                          0098000
            99*   160 R3(I,1)=R3(I,1)-0.5*VZ(I,2)*(R2(I,2)-R2(I,1))/DZ2(2)                 0099000
           100*       DO 170 I=1,M1                                                          0100000
           101*   170 R3(I,M1)=R3(I,M1)-0.5*VZ(I,M1)*(R(I,M1)-R(I,M2))/DZ2(M1)             0101000
           102* C                                                                           0102000
           103* C                    INERTIA TERMS FOR HORIZONTAL MOMENTUM                  0103000
           104* C                                                                           0104000
           105*       DO 110 J=1,M1                                                          0105000
           106*       DO 110 I=2,M1                                                          0106000
           107*       VR3(I,J)=VR3(I,J)+VT(I,J)*(VT(I,J)/R1(I)+C0RI)                         0107000
           108*   110 VT3(I,J)=VT3(I,J)-VR(I,J)*(VT(I,J)/R1(I)+C0RI)                         0108000
           109* C                                                                           0109000
           110* C                    BUOYANCY TERM FOR VERTICAL ACCELERATION                0110000
           111* C                                                                           0111000
           112*       DO 120 J=2,M1                                                          0112000
           113*       DO 120 I=1,M1                                                          0113000
           114*   120 VZ3(I,J)=VZ3(I,J)-0.5*(R(I,J)+B(I,J-1))                               0114000
           115* C                                                                           0115000
           116* C                    STRATIFICATION TERM                                    0116000
           117* C                                                                           0117000
           118*       DO 130 J=1,M1                                                          0118000
           119*       DO 130 I=1,M1                                                          0119000
           120*   130 R3(I,J)=R3(I,J)+0.5*(VZ(I,J)*BV2(J)+VZ(I,J+1)*BV2(J+1))               0120000
           121*       RETURN                                                                 0121000
           122*       END                                                                    0122000

*** MEMBER ADVECT   ADDED TO    SOURCE  --   122 RECORDS
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CARD IMAGE FILE EDITOR(CIFED) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER PLTOUT

 1*        SUBROUTINE PUTPLT                                                     0001000
 2*        PARAMETER M=21,N=21                                                   0002000
 3*        PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                 0003000
 4*        COMMON/ONE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),B1(M1,N1),VR2(M,N1),         0004000
 5*       1           VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),       0005000
 6*       2           VZ3(M1,N),B3(M1,N1),P(M1,N1)                             0006000
 7*        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)    0007000
 8*        COMMON/THR/RHO,EMER(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N)     0008000
 9*        COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMO,ITAPE,TBV                      0009000
10* C                                                                            0010000
11* C                    THIS SUBROUTINE PRINT OUT FIELDS FOR A QUICK LOOK       0011000
12* C                                                                            0012000
13*        DIMENSION IDUM(M,N)                                                   0013000
14*   700 FORMAT(/////,'  RADIAL VELOCITY (CM/S) AT T=',I6,' M')                 0014000
15*   705 FORMAT(/////,'  TANGENTIAL VELOCITY (CM/S) AT T=',I6,' M')             0015000
16*   710 FORMAT(/////,'  VERTICAL VELOCITY (CM/S) AT T=',I6,' M')               0016000
17*   715 FORMAT(/////,'  BUOYANCY FIELD (*.001) AT T=',I6,' M')                 0017000
18*   725 FORMAT(/////,'  PRESSURE (*10 DYNE/CM**2) AT TIME=',I6,' M')           0018000
19*   720 FORMAT(1H1,////,20X,'**********   OUTPUT AT TIME =',I6,' M     OR',  0019000
20*      1 F8.2,' DAY      ISTEP =',I7,'    **************')                     0020000
21*        DAY=XTIME/86400.+1.0001                                               0021000
22*        PRINT 720,ITIME,DAY,ISTEP                                             0022000
23*        DO 10 J=1,N1                                                          0023000
24*        DO 10 I=1,M                                                           0024000
25*     10 IDUM(I,J)=VR2(I,J)                                                    0025000
26*        PRINT 700,ITIME                                                       0026000
27*        CALL MAP(IDUM,R1,Z2,M,N1)                                             0027000
28*        DO 20 J=1,N1                                                          0028000
29*        DO 20 I=1,M                                                           0029000
30*     20 IDUM(I,J)=VT2(I,J)                                                    0030000
31*        PRINT 705,ITIME                                                       0031000
32*        CALL MAP(IDUM,R1,Z2,M,N1)                                             0032000
33*        DO 30 J=1,N                                                           0033000
34*        DO 30 I=1,M1                                                          0034000
35*     30 IDUM(I,J)=VZ2(I,J)                                                    0035000
36*        PRINT 710,ITIME                                                       0036000
37*        CALL MAP(IDUM,R2,Z1,M1,N)                                             0037000
38*        DO 40 J=1,N1                                                          0038000
39*        DO 40 I=1,M1                                                          0039000
40*     40 IDUM(I,J)=B2(I,J)*1.E3                                                0040000
41*        PRINT 715,ITIME                                                       0041000
42*        CALL MAP(IDUM,R2,Z2,M1,N1)                                            0042000
43*        DO 50 J=1,N1                                                          0043000
44*        DO 50 I=1,M1                                                          0044000
45*     50 IDUM(I,J)=P(I,J)*1.E-1                                                0045000
46*        PRINT 725,ITIME                                                       0046000
47*        CALL MAP(IDUM,R2,Z2,M1,N1)                                            0047000
48*        RETURN                                                                0048000
49*        END                                                                   0049000
```

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CARD IMAGE FILE EDITOR(CIFED) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER MAP

  1*        SUBROUTINE MAP(A,R,Z,MM,NN)                                    0001000
  2*        PARAMETER MB=21,NB=21                                          0002000
  3*        DIMENSION R(MM),Z(NN)                                          0003000
  4*        INTEGER A (M,N),IR(M),IZ(N)                                    0004000
  5*     70 FORMAT(1HS,7X,25I5)                                            0005000
  6*     80 FORMAT(1HS,I4,3X,25I5)                                         0006000
  7*        MP=MIN0(25,MM)                                                 0007000
  8*        DO 10 I=1,MP                                                   0008000
  9*     10 IR(I)=R(I)+1.E-5+.1                                            0009000
 10*        DO 20 J=1,NN                                                   0010000
 11*     20 IZ(J)=Z(J)+1.E-5+0.1                                           0011000
 12*        PRINT 70                                                       0012000
 13*        PRINT 70,(IR(I),I=1,MP)                                        0013000
 14*        PRINT 70                                                       0014000
 15*        DO 30 JJ=1,NN                                                  0015000
 16*        J=NN+1-JJ                                                      0016000
 17*     30 PRINT 80,IZ(J),(A(I,J),I=1,MP)                                 0017000
 18*        RETURN                                                         0018000
 19*        END                                                            0019000
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CARD IMAGE FILE EDITOR(CIFED) ** VERSION 05.29  DATE=10/26/82        TIME=14:12:12:99

*** PENMEN PRESS

      1*        SUBROUTINE PRESS                                                0001000
      2* C                                                                       0002000
      3* C                    THIS SUBROUTINE SETS UP FORCING FUNCTIONS AND BOUNDARY0003000
      4* C                    CONDITIONS FOR THE PRESSURE DIAGNOSTIC EQUATIONS FOR S0004000
      5* C                                                                       0005000
      6*        PARAMETER M=21,N=21                                             0006000
      7*        PARAMETER M1=M+1,M2=M+2,N1=N+1,N2=N+2                           0007000
      8*        PARAMETER NBLK=2,NBLK1=NBLK+1                                   0008000
      9*        REAL*8 RCOR,RINV,RINV1,HTILDA,DUMMY1                           0009000
     10*        COMMON/CBLE/VR1(M,N1),VT1(M,N1),VZ1(M1,N),B1(M1,N1),VR2(M,N1),  0010000
     11*       1            VT2(M,N1),VZ2(M1,N),B2(M1,N1),VR3(M,N1),VT3(M,N1),  0011000
     12*       2            VZ3(M1,N),B3(M1,N1),P(M1,N1)                        0012000
     13*        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N) 0013000
     14*        COMMON/THR/RHO,RHOR(N1),RV2(N),ALPHA,BNDA,BNDR,CORI,G,HH(M),ZK(N)  0014000
     15* C                                                                       0015000
     16* C                      MP=NP IS THE SIZE OF X AND F                     0016000
     17* C                      MP=M1+2,NP=N1+NBLK+1                             0017000
     18* C                                                                       0018000
     19*        PARAMETER MP=M+1,NP=N+1                                         0019000
     20*        PARAMETER MP1=MP+1,MP2=MP+2,NP1=NP+1,NP2=NP+2                   0020000
     21*        COMMON/EVP/RINV(MP2,MP2,NBLK),RINV1(MP2,MP2,NBLK1),RCOR(MP,3),  0021000
     22*       1            HTILDA(MP2),F(MP,NP),NBSIZ2(NBLK),IS(NBLK),SUMF(NBLK),  0022000
     23*       2            IE(NBLK),F1I(MP),F1N(MP),F2I(NP),F2M(NP),AX(MP),AY(NP),  0023000
     24*       3            BB(MP,NP),CX(MP),CY(NP)                             0024000
     25*        DIMENSION DUMMY1(MP2,MP2),X(MP,NP)                              0025000
     26*        EQUIVALENCE(DUMMY1,RINV(1,1,NBLK))                              0026000
     27*        PARAMETER MPMP=MP*MP                                            0027000
     28*        DATA DUMMY1/MPMP*0./,X/MPMP*0./                                 0028000
     29*        DATA NCALL/0/                                                   0029000
     30* C  NBSIZ2 REPRESENTS NUMBER OF INTERIOR GRID POINTS IN EACH BLOCK IN X-DI0030000
     31* C N2 REPRESENTS NUMBER OF INTERIOR GRID POINTS IN Y-DIRECTION           0031000
     32* C NBLK REPRESENTS NUMBER OF BLOCKS IN X-DIRECTION                       0032000
     33* C THE VARIABLES A11,A1N,A21,A2M TAKES THE VALUE 0 FOR DIRICHLET B.C.    0033000
     34* C  AND 1 FOR NEUMANN B.C.  AT THEIR RESPECTIVE BOUNDARIES  A11 CORRESPOND0034000
     35* C  J=1     A1N TO J=N          A21   TO I=1      A2M   TO I=M           0035000
     36* C BOUNDARY CONDITIONS ARE                                               0036000
     37* C   X(I,1)=(1-A11)*X(I,1)+A11*(X(I,2)-F1I(I))                           0037000
     38* C     X(I,NP)=(1-A1N)*X(I,NP)+A1N*(X(I,NP-1)+F1N(I))                    0038000
     39* C   X(1,J)=(1-A21)*X(1,J)+A21*(X(2,J)-F2I(J))                          0039000
     40* C     X(MP,J)=(1-A2M)*X(MP,J)+A2M*(X(MP-1,J)+F2M(J))                    0040000
     41*        NCALL=NCALL+1                                                   0041000
     42* C                                                                       0042000
     43* C                      DEFINE THE FORCING FUNCTION OF THE ELLIPTIC EQUATION 0043000
     44* C                                                                       0044000
     45*        DO 10 J=1,NP2                                                   0045000
     46*        DO 10 I=1,MP2                                                   0046000
     47*     10 F(I+1,J+1)=((X(I+1)-DR2(I+1)+VR3(I+1,J)+VZ3(I,J+1)/DZ1(J)       0047000
     48*       1            -AX(I+1)*DR2(I)*VR3(I,J)-VZ3(I,J)/DZ1(J))*RHO      0048000
     49* C                                                                       0049000
     50* C                      SET UP AN INITIAL GUESS                          0050000
     51* C                                                                       0051000
```

*** MEMMEM PRESS

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      IF(NCALL.GT.1)GO TO 30                                                    0052000
      DO 20 J=1,NP2                                                             0053000
      DO 20 I=1,MP2                                                             0054000
   20 X(I+1,J+1)=P(I,J)                                                         0055000
   30 CONTINUE                                                                  0056000
      CALL ZILCH(F11,MP)                                                        0057000
      CALL ZILCH(F1N,MP)                                                        0058000
      CALL ZILCH(F21,NP)                                                        0059000
C                                                                               0060000
C                     DEFINE THE FORCING AT BOUNDARY SO THAT THERE              0061000
C                     IS GRADIENT BALANCE AT OUTER BOUNDARY                     0062000
C                                                                               0063000
      DO 605 J=2,NP1                                                            0064000
      F2M(J)=RHO*DR2(M)*VT2(M,J-1)*(VT2(M,J-1)/R1(M)+CORI)                      0065000
  605 CONTINUE                                                                  0066000
      A11=1                                                                     0067000
      A1N=1                                                                     0068000
      A21=1                                                                     0069000
      A2M=1                                                                     0070000
      DO 101  J=2,NP1                                                           0071000
      BB(2,J)=BB(2,J)+AX(2)*A21                                                 0072000
      F(2,J)=F(2,J)+AX(2)*F21(J)*A21                                            0073000
      X(1,J)=(1.0-A21)*X(1,J)                                                   0074000
      BB(MP-1,J)=BB(MP-1,J)+CX(MP-1)*A2M                                        0075000
      F(MP-1,J)=F(MP-1,J)-CX(MP-1)*F2M(J)*A2M                                   0076000
      X(MP,J)=(1.0-A2M)*X(MP,J)                                                 0077000
  101 CONTINUE                                                                  0078000
      DO 102 I=2,NP1                                                            0079000
      BB(I,2)=BB(I,2)+AY(2)*A11                                                 0080000
      F(I,2)=F(I,2)+AY(2)*F11(I)*A11                                            0081000
      X(I,1)=(1.0-A11)*X(I,1)                                                   0082000
      BB(I,NP-1)=BB(I,NP-1)+CY(NP-1)*A1N                                        0083000
      F(I,NP-1)=F(I,NP-1)-CY(NP-1)*F1N(I)*A1N                                   0084000
      X(I,NP)=(1.0-A11)*X(I,NP)                                                 0085000
  102 CONTINUE                                                                  0086000
      IF(NCALL.EQ.1)CALL BSM1                                                   0087000
      ERRPR=1.E-3                                                               0088000
      CALL BSM2(X,ERRPR,A11,A1N,A21,A2M)                                        0089000
C                                                                               0090000
C                     DEFINE THE DIAGNOSED PRESSURE                             0091000
C                                                                               0092000
      DO 110 J=1,M1                                                             0093000
      DO 110 I=1,M1                                                             0094000
  110 P(I,J)=X(I+1,J+1)                                                         0095000
  115 CONTINUE                                                                  0096000
C                                                                               0097000
C                     AND PRESSURE GRADIENT FORCES TO VR3 AND VZ3               0098000
C                                                                               0099000
      DO 120 J=1,M1                                                             0100000
      DO 120 I=2,M1                                                             0101000
  120 VR3(I,J)=VR3(I,J)-(P(I,J)-P(I-1,J))/(RHO*DR2(I))                          0102000
      DO 130 J=2,M1                                                             0103000
      DO 130 I=1,M1                                                             0104000
  130 VZ3(I,J)=VZ3(I,J)-(P(I,J)-P(I,J-1))/(RHO*DZ2(J))                          0105000
      RETURN                                                                    0106000
      END                                                                       0107000
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CARD IMAGE FILE EDITOR(CIFED) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12.99

*** MEMBER BSM1

                1*        SUBROUTINE BSM1                                                                 0001000
                2*        PARAMETER MB=21,NB=1                                                            0002000
                3*        PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                           0003000
                4*        PARAMETER MP=M+1,NP=N+1                                                         0004000
                5*        PARAMETER MP1=MP-1,MP2=MP-2,NP1=NP-1,NP2=NP-2                                   0005000
                6*        PARAMETER NBLK=2,NBLK1=NBLK-1                                                   0006000
                7*        REAL*8 RCOR,RINV,RINV1,RTILDA,DUMMY1                                            0007000
                8*        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)              0008000
                9*        COMMON/CVP/RINV(MP2,MP2,NBLK),RINV1(MP2,MP2,NBLK1),RCOR(MP,3),                 0009000
               10*       1            RTILDA(MP2),F(MP,NP),NBSIZ2(NBLK),IS(NBLK),SUMF(NBLK),            0010000
               11*       2            IE(NBLK),F11(MP),F1N(MP),F21(NP),F2M(NP),AX(MP),AY(NP),           0011000
               12*       3            BB(MP,NP),CX(MP),CY(NP)                                           0012000
               13*        DIMENSION DUMMY1(MP2,MP2)                                                       0013000
               14*        EQUIVALENCE (DUMMY1,RINV(1,1,NBLK))                                             0014000
               15*        IE(1)=NBSIZ2(1)+2                                                               0015000
               16*        DO 90 NB=2,NBLK                                                                 0016000
               17*        IE(NB)=IE(NB-1)+NBSIZ2(NB)+1                                                    0017000
               18*     90 CONTINUE                                                                        0018000
               19*        DO 95 NB=1,NBLK1                                                                0019000
               20*        IS(NB+1)=IE(NB)+1                                                               0020000
               21*     95 CONTINUE                                                                        0021000
               22*        IS(1)=1                                                                         0022000
               23*        DO 115 I1=1,MP2                                                                 0023000
               24*        DO 110 J=1,3                                                                    0024000
               25*        DO 110 I=1,MP                                                                   0025000
               26*        RCOR(I,J)=0.0                                                                   0026000
               27*    110 CONTINUE                                                                        0027000
               28*        RCOR(I1+1,2)=1.0                                                                0028000
               29*        NPS=IE(1)+1                                                                     0029000
               30*        DO 130 J1=2,NPS                                                                 0030000
               31*        DO 135 I=2,MP1                                                                  0031000
               32*        RCOR(I,3)=(-AX(I)*RCOR(I-1,2)-AY(J1)*RCOR(I,1)-BB(I,J1)*                        0032000
               33*       1RCOR(I,2)-CX(I)*RCOR(I+1,2))/CY(J1)                                             0033000
               34*    135 CONTINUE                                                                        0034000
               35*        DO 140 I=1,MP                                                                   0035000
               36*        RCOR(I,1)=RCOR(I,2)                                                             0036000
               37*        RCOR(I,2)=RCOR(I,3)                                                             0037000
               38*    140 CONTINUE                                                                        0038000
               39*    130 CONTINUE                                                                        0039000
               40*        DO 145 I=1,MP2                                                                  0040000
               41*        RINV(I1,I,1)=RCOR(I+1,1)                                                        0041000
               42*        DUMMY1(I1,I)=RCOR(I+1,2)                                                        0042000
               43*    145 CONTINUE                                                                        0043000
               44*    115 CONTINUE                                                                        0044000
               45*        CALL MATINV(DUMMY1)                                                             0045000
               46*        DO 160 I=1,MP2                                                                  0046000
               47*        DO 160 J=1,MP2                                                                  0047000
               48*        RINV1(I,J,1)=0.0                                                                0048000
               49*        DO 161 K=1,MP2                                                                  0049000
               50*        RINV1(I,J,1)=RINV1(I,J,1)+DUMMY1(I,K)*RINV(K,J,1)                               0050000
               51*    161 CONTINUE                                                                        0051000
               52*    160 CONTINUE                                                                        0052000
               53*        DO 170 I=1,MP2                                                                  0053000
               54*        DO 170 J=1,MP2                                                                  0054000
               55*        RINV(I,J,1)=DUMMY1(I,J)                                                         0055000
               56*    170 CONTINUE                                                                        0056000
               57*        DO 205 NB=2,NBLK                                                                0057000
               58*        DO 215 I1=1,MP2                                                                 0058000
               59*        DO 210 J=1,3                                                                    0059000
               60*        DO 210 I=1,MP                                                                   0060000
               61*        RCOR(I,J)=0.0                                                                   0061000
               62*    210 CONTINUE                                                                        0062000
               63*        DO 220 I=1,MP2                                                                  0063000
               64*        RCOR(I+1,1)=RINV(I1,I,NB-1)                                                     0064000
               65*    220 CONTINUE                                                                        0065000
               66*        RCOR(I1+1,2)=1.0                                                                0066000
               67*        IE1=IE(NB-1)                                                                    0067000
               68*        IE2=IE(NB)-1                                                                    0068000
               69*        IF(NB.LT.NBLK) GO TO 232                                                        0069000
               70*        IE2=IE2+1                                                                       0070000
               71*    232 CONTINUE                                                                        0071000
               72*        DO 230 J1=IE1,IE2                                                               0072000
               73*        DO 235 I=2,MP1                                                                  0073000
               74*        RCOR(I,3)=(-AX(I)*RCOR(I-1,2)-AY(J1)*RCOR(I,1)-BB(I,J1)*                        0074000
               75*       1RCOR(I,2)-CX(I)*RCOR(I+1,2))/CY(J1)                                             0075000
               76*    235 CONTINUE                                                                        0076000
               77*        DO 240 I=1,MP
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER BSM1
                                                                      0077000
      78*       RCAM(I,1)=RCOR(I,2)                                   0078000
      79*       RCAM(I,2)=RCOR(I,3)                                   0079000
      80*   240 CONTINUE                                              0080000
      81*   241 CONTINUE                                              0081000
      82*   230 CONTINUE                                              0082000
      83*       IF(NM.EQ.NBLK) GO TO 246                              0083000
      84*       DO 245 I=1,MP2                                        0084000
      85*       RINV(II,I,NB)=RCOR(I+1,1)                             0085000
      86*   245 CONTINUE                                              0086000
      87*       DO 247 I=1,MP2                                        0087000
      88*       DUMMY1(I1,I)=RCOR(I+1,2)                              0088000
      89*   247 CONTINUE                                              0089000
      90*       GO TO 249                                             0090000
      91*   246 CONTINUE                                              0091000
      92*       DO 248 I=2,MP1                                        0092000
      93*       DUMMY1(I1,I-1)=AX(I)*RCOR(I-1,2)+AY(NP-1)*RCOR(I,1)+  0093000
      94*      1RR(I,NP-1)*RCOR(I,2)+CX(I)*RCOR(I+1,2)                0094000
      95*   248 CONTINUE                                              0095000
      96*   249 CONTINUE                                              0096000
      97*   215 CONTINUE                                              0097000
      98*       CALL MATINV(DUMMY1)                                   0098000
      99*       IF(NM.EQ.NBLK) GO TO 275                              0099000
     100*       DO 260 J=1,MP2                                        0100000
     101*       DO 260 I=1,MP2                                        0101000
     102*       RINV1(I,J,NB)=0.0                                     0102000
     103*       DO 261 K=1,MP2                                        0103000
     104*       RINV1(I,J,NB)=RINV1(I,J,NB)+DUMMY1(I,K)*RINV(K,J,NB)  0104000
     105*   261 CONTINUE                                              0105000
     106*   260 CONTINUE                                              0106000
     107*       DO 270 J=1,MP2                                        0107000
     108*       DO 270 I=1,MP2                                        0108000
     109*       RINV(I,J,NB)=DUMMY1(I,J)                              0109000
     110*   270 CONTINUE                                              0110000
     111*   275 CONTINUE                                              0111000
     112*   235 CONTINUE                                              0112000
     113*       RETURN                                                0113000
     114*       END                                                   0114000
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CARD IMAGE FILE EDITOR(CYBER) -- VERSION 05.29  DATE=10/26/82        TIME=14:12:12:99

*** MEMBER MATINV

  1*        S UBROUTINE MATINV(B)                                                 0001000
  2*        PARAMETER MP=21                                                       0002000
  3*        PARAMETER MP1=MP+1                                                    0003000
  4*        REAL*8 B(MP,MP)                                                       0004000
  5*        REAL*8 B1(MP),B2(MP)                                                  0005000
  6*        MP1=MP+1                                                              0006000
  7*        DO 110 I=1,MP1                                                        0007000
  8*        B1(1)=1.0/B(I,I)                                                      0008000
  9*        B(I,I)=1.0                                                            0009000
 10*        DO 11C J=1,MP                                                         0010000
 11*        B(I,J)=B(I,J)*B1(1)                                                   0011000
 12*    112 CONTINUE                                                              0012000
 13*        IP1=I+1                                                               0013000
 14*        DO 120 II=IP1,MP                                                      0014000
 15*        B1(II)=B(II,I)                                                        0015000
 16*    120 CONTINUE                                                              0016000
 17*        DO 125 II=IP1,MP                                                      0017000
 18*        B(II,I)=0.0                                                           0018000
 19*    125 CONTINUE                                                              0019000
 20*        DO 127 J=1,MP                                                         0020000
 21*        B2(J)=B(I,J)                                                          0021000
 22*    127 CONTINUE                                                              0022000
 23*        DO 135 II=IP1,MP                                                      0023000
 24*        DO 135 J=1,MP                                                         0024000
 25*        B(II,J)=B(II,J)-B1(II)*B2(J)                                          0025000
 26*    135 CONTINUE                                                              0026000
 27*    110 CONTINUE                                                              0027000
 28*        B1(1)=1.0/B(MP,MP)                                                    0028000
 29*        B(MP,MP)=1.0                                                          0029000
 30*        DO 140 J=1,MP                                                         0030000
 31*        B(MP,J)=B(MP,J)*B1(1)                                                 0031000
 32*    140 CONTINUE                                                              0032000
 33*        DO 150 I=2,MP                                                         0033000
 34*        DO 155 I2=1,I                                                         0034000
 35*        B1(I2)=B(I2,I)                                                        0035000
 36*    155 CONTINUE                                                              0036000
 37*        IM1=I-1                                                               0037000
 38*        DO 156 I2=1,IM1                                                       0038000
 39*        B(I2,I)=0.0                                                           0039000
 40*    156 CONTINUE                                                              0040000
 41*        DO 157 J=1,MP                                                         0041000
 42*        B2(J)=B(I,J)                                                          0042000
 43*    157 CONTINUE                                                              0043000
 44*        IM1=I-1                                                               0044000
 45*        DO 160 I2=1,IM1                                                       0045000
 46*        DO 160 J=1,MP                                                         0046000
 47*        B(I2,J)=B(I2,J)-B1(I2)*B2(J)                                          0047000
 48*    160 CONTINUE                                                              0048000
 49*    150 CONTINUE                                                              0049000
 50*        RETURN                                                                0050000
 51*        END                                                                   0051000
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CARD IMAGE FILE EDITOR(CIFED) -- VERSION 05.29  DATE=10/26/82       TIME=14112112199

*** MEMBER BSM2

      1*       SUBROUTINE BSM2(X,ERROR,A11,A1N,A21,A2M)                                  0001000
      2*       PARAMETER M=21,N=21                                                       0002000
      3*       PARAMETER NBLK=2,NBLK1=NBLK-1                                             0003000
      4*       PARAMETER MP=M+1,NP=N+1                                                   0004000
      5*       PARAMETER MP1=MP-1,MP2=MP-2,NP1=NP-1,NP2=NP-2                             0005000
      6*       REAL*8 RCOR,RINV,RINV1,RTILDA                                             0006000
      7*       COMMON/EVP/RINV(MP2,MP2,NBLK),RINV1(MP2,MP2,NBLK1),RCOR(MP,3),            0007000
      8*      1           RTILDA(MP2),F(MP,NP),NPSIZ2(NBLK),IS(NPLK),SUMF(NBLK),       0008000
      9*      2           IE(NPLK),F11(MP),F1N(MP),F21(NP),F2M(NP),AX(MP),AY(NP),      0009000
     10*      3           BB(MP,NP),CX(MP),CY(NP)                                       0010000
     11*       DIMENSION X(MP,NP)                                                        0011000
     12*       DO 90 NB=1,NBLK                                                           0012000
     13*       SUMF(NB)=0.0                                                              0013000
     14*    90 CONTINUE                                                                  0014000
     15*       DO 95 NB=1,NBLK                                                           0015000
     16*       DO 95 I=2,MP1                                                             0016000
     17*       SUMF(NB)=SUMF(NB)+ABS(F(I,IE(NB)-1))                                      0017000
     18*    95 CONTINUE                                                                  0018000
     19*       DO 96 NB=1,NBLK                                                           0019000
     20*       IF(SUMF(NB).GT.1.0) GO TO 96                                              0020000
     21*       SUMF(NB)=1.0                                                              0021000
     22*    96 CONTINUE                                                                  0022000
     23*       NSTART=1                                                                  0023000
     24*       DO 199 IT3=1,5                                                            0024000
     25*       DO 200 NB=NSTART,NBLK                                                     0025000
     26*       IS1=IS(NB)+1                                                              0026000
     27*       IE=IE(NB)-2                                                               0027000
     28*       DO 205 J=IS1,IE                                                           0028000
     29*       DO 205 I=2,MP1                                                            0029000
     30*       X(I,J+1)=(F(I,J)-AX(I)*X(I-1,J)-AY(J)*X(I,J-1)-BB(I,J)*                   0030000
     31*      1X(I,J)-CX(I)*X(I+1,J))/CY(J)                                              0031000
     32*   205 CONTINUE                                                                  0032000
     33*       IF(NB.EQ.NBLK) GO TO 200                                                  0033000
     34*       DO 522 IT=1,11                                                            0034000
     35*       J1=IE(NB)-1                                                               0035000
     36*       DO 215 I=2,MP1                                                            0036000
     37*       RTILDA(I-1)=X(I,J1+1)-(F(I,J1)-AX(I)*X(I-1,J1)-AY(J1)*                    0037000
     38*      1X(I,J1-1)-BB(I,J1)*X(I,J1)          -CX(I)*X(I+1,J1))/CY(J1)             0038000
     39*   215 CONTINUE                                                                  0039000
     40*       A2=0.0                                                                    0040000
     41*       DO 216 I=1,MP2                                                            0041000
     42*       A2=A2+DABS(RTILDA(I))                                                     0042000
     43*   216 CONTINUE                                                                  0043000
     44*       A3=A2/SUMF(NB)                                                            0044000
     45*       IF(A3.LE.0.1) GO TO 230                                                   0045000
     46*       DO 217 J=1,3                                                              0046000
     47*       DO 217 I=1,MP                                                             0047000
     48*       RCOR(I,J)=0.0                                                             0048000
     49*   217 CONTINUE                                                                  0049000
     50*       DO 223 J=1,MP2                                                            0050000
     51*       RCOR(J+1,2)=0.0                                                           0051000
     52*       DO 223 J1=1,MP2                                                           0052000
     53*       RCOR(J+1,2)=RCOR(J+1,2)+RTILDA(J1)*RINV(J1,J,NB)                          0053000
     54*   223 CONTINUE                                                                  0054000
     55*       IF(NB.EQ.1) GO TO 251                                                     0055000
     56*       DO 225 J=2,MP1                                                            0056000
     57*       RCOR(J,1)=0.0                                                             0057000
     58*       DO 225 K=2,MP1                                                            0058000
     59*       RCOR(J,1)=RCOR(J,1)          +RCOR(K,2)*RINV1(K-1,J-1,NB-1)               0059000
     60*   225 CONTINUE                                                                  0060000
     61*       DO 226 I=2,MP1                                                            0061000
     62*       X(I,IS(NB))=X(I,IS(NB))+RCOR(I,1)                                         0062000
     63*   226 CONTINUE                                                                  0063000
     64*   251 CONTINUE                                                                  0064000
     65*       CALL BSM3(X,IS(NB),IE(NB))                                                0065000
     66*   522 CONTINUE                                                                  0066000
     67*   230 CONTINUE                                                                  0067000
     68*       J1=IE(NB)-1                                                               0068000
     69*       DO 220 I=2,MP1                                                            0069000
     70*       X(I,J1+1)=(F(I,J1)-AX(I)*X(I-1,J1)-AY(J1)*X(I,J1-1)-                      0070000
     71*      1BB(I,J1)*X(I,J1)-CX(I)*X(I+1,J1))/CY(J1)                                  0071000
     72*   220 CONTINUE                                                                  0072000
     73*   501 CONTINUE                                                                  0073000
     74*   200 CONTINUE                                                                  0074000
     75*       DO 300 NB=1,NBLK                                                          0075000
     76*       NP=NBLK -NB+1                                                             0076000
     77*       IS1=IS(NB)+1                                                              0077000
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*** MEMBER BSM2
                78*       IE=2=IE(NB)+2                                                          0078000
                79*       J=IE=2                                                                 0079000
                80*       IF(NB.EQ.NBLK) GO TO 502                                               0080000
                81*       DO 305 I=2,MP1                                                         0081000
                82*       X(I,J+1)=(F(I,J)-AX(I)*X(I-1,J)-AY(J)*X(I,J-1)-BB(I,J)*                0082000
                83*      1X(I,J)-CX(I)*X(I+1,J))/CY(J)                                           0083000
                84*   305 CONTINUE                                                               0084000
                85*   502 CONTINUE                                                               0085000
                86*       DO 552 IT=1,10                                                         0086000
                87*       IF(NB.EQ.NBLK) GO TO 317                                               0087000
                88*       J1=IE(NB)+1                                                            0088000
                89*       DO 315 I=2,MP1                                                         0089000
                90*       RTILDA(I-1)=X(I,J1+1)-(F(I,J1)-AX(I)*X(I-1,J1)-AY(J1)*                 0090000
                91*      1X(I,J1-1)-BB(I,J1)*X(I,J1)-CX(I)*X(I+1,J1))/CY(J1)                     0091000
                92*   315 CONTINUE                                                               0092000
                93*       GO TO 318                                                              0093000
                94*   317 CONTINUE                                                               0094000
                95*       DO 319 I=2,MP1                                                         0095000
                96*       RTILDA(I-1)=F(I,NP-1)-(AX(I)*X(I-1,NP-1)+AY(NP-1)*X(I,NP-2)+           0096000
                97*      1BB(I,NP-1)*X(I,NP-1)+CX(I)*X(I+1,NP-1))                                0097000
                98*   319 CONTINUE                                                               0098000
                99*   318 CONTINUE                                                               0099000
               100*       A2=0.0                                                                 0100000
               101*       DO 316 I=1,MP2                                                         0101000
               102*       A2=A2+DABS(RTILDA(I   ))                                               0102000
               103*   316 CONTINUE                                                               0103000
               104*       A3=A2/SUMF(NB)                                                         0104000
               105*       IF(A3.LE.ERROR) GO TO 300                                              0105000
               106*       DO 320 J=1,3                                                           0106000
               107*       DO 320 I=1,MP                                                          0107000
               108*       RCOR(I,J)=0.0                                                          0108000
               109*   320 CONTINUE                                                               0109000
               110*       DO 324 J=1,MP2                                                         0110000
               111*       RCOR(J+1,2)=0.0                                                        0111000
               112*       DO 324 J1=1,MP2                                                        0112000
               113*       RCOR(J+1,2)=RCOR(J+1,2)+RTILDA(J1)*RINV(J1,J,NB)                       0113000
               114*   324 CONTINUE                                                               0114000
               115*       IF(NB.EQ.1) GO TO 551                                                  0115000
               116*       DO 325 J=2,MP1                                                         0116000
               117*       RCOR(J,1)=0.0                                                          0117000
               118*       DO 325 K=2,MP1                                                         0118000
               119*       RCOR(J,1)=RCOR(J,1)          +RCOR(K,2)*RINV1(K-1,J-1,NB-1)            0119000
               120*   325 CONTINUE                                                               0120000
               121*       DO 326 I=2,MP1                                                         0121000
               122*       X(I,IS(NB))=X(I,IS(NB))+RCOR(I,1)                                      0122000
               123*   326 CONTINUE                                                               0123000
               124*   551 CONTINUE                                                               0124000
               125*       CALL BSM3(X,IS(NB),IE(NB))                                             0125000
               126*   552 CONTINUE                                                               0126000
               127*   300 CONTINUE                                                               0127000
               128*       J1=IE(1)                                                               0128000
               129*       DO 330 I=2,MP1                                                         0129000
               130*       RTILDA(I-1)=X(I,J1+1)-(F(I,J1)-AX(I)*X(I-1,J1)-AY(J1)*                 0130000
               131*      1X(I,J1-1)-BB(I,J1)*X(I,J1)          -CX(I)*X(I+1,J1))/CY(J1)          0131000
               132*   330 CONTINUE                                                               0132000
               133*       A2=0.0                                                                 0133000
               134*       DO 332 I=1,MP2                                                         0134000
               135*       A2=A2+DABS(RTILDA(I))                                                  0135000
               136*   332 CONTINUE                                                               0136000
               137*       A3=A2/SUMF(1)                                                          0137000
               138*       IF(A3.LE.ERROR) GO TO 201                                              0138000
               139*       NSTART=2                                                               0139000
               140*   199 CONTINUE                                                               0140000
               141*   201 CONTINUE                                                               0141000
               142*       DO 350 J=2,MP1                                                         0142000
               143*       X(1,J)=(1.0-A21)*X(1,J)+A21*(X(2,J)-F21(J))                            0143000
               144*       X(MP,J)=(1.0-A2M)*X(MP,J)+A2M*(X(MP-1,J)+F2M(J))                       0144000
               145*   350 CONTINUE                                                               0145000
               146*       DO 360 I=2,MP1                                                         0146000
               147*       X(I,1)=(1.0-A11)*X(I,1)+A11*(X(I,2)+F11(I))                            0147000
               148*       X(I,NP)=(1.0-A1N)*X(I,NP)+A1N*(X(I,NP-1)+F1N(I))                       0148000
               149*   360 CONTINUE                                                               0149000
               150*       DO 371 J=2,MP1                                                         0150000
               151*       BB(2,J)=BB(2,J)-AX(2)*A21                                              0151000
               152*       F(2,J)=F(2,J)-AX(2)*F21(J)*A21                                         0152000
               153*       BB(MP-1,J)=BB(MP-1,J)-CX(MP-1)*A2M                                     0153000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER HSM2

      154*          F(MP-1,J)=F(MP-1,J)+CX(MP-1)*F2M(J)*A2M                    0154000
      155*   371 CONTINUE                                                      0155000
      156*       DO 372 I=2,MP1                                                0156000
      157*       BB(I,2)=BB(I,2)-AY(2)*A11                                     0157000
      158*       F(I,2)=F(I,2)-AY(2)*F11(I)*A11                                0158000
      159*       BB(I,MP-1)=BB(I,MP-1)-CY(MP-1)*A1N                            0159000
      160*       F(I,MP-1)=F(I,MP-1)+CY(MP-1)*F1N(I)*A1N                       0160000
      161*   372 CONTINUE                                                      0161000
      162*       RETURN                                                        0162000
      163*       END                                                           0163000
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CARD IMAGE FILE EDITOR(CIFED) -- VERSION 05.29  DATE=10/26/82       TIME=14:12:12:99

*** MEMBER BSM3

                1*       SUBROUTINE BSM3(X,ISS,IEE)                                              0001000
                2*       PARAMETER M=21,N=21                                                     0002000
                3*       PARAMETER NBLK=2,NBLK1=NBLK-1                                           0003000
                4*       PARAMETER MP=M+1,NP=N+1                                                 0004000
                5*       PARAMETER MP1=MP-1,MP2=MP-2,NP1=NP-1,NP2=NP-2                           0005000
                6*       REAL*8 RCOR,RINV,RINV1,RTILDA                                           0006000
                7*       DIMENSION X(MP,NP)                                                      0007000
                8*       COMMON/EVP/RINV(MP2,MP2,NBLK),RINV1(MP2,MP2,NBLK1),RCOR(MP,3),          0008000
                9*      1           RTILDA(MP2),F(MP,NP),NBSIZ2(NBLK),IS(NBLK),SLMF(NBLK),      0009000
               10*      2           IE(NBLK),F11(MP),F1N(MP),F21(NP),F2M(NP),AX(MP),AY(NP),     0010000
               11*      3           BB(MP,NP),CX(MP),CY(NP)                                     0011000
               12*       DO 135 I=2,MP1                                                          0012000
               13*       X(I,ISS+1)=X(I,ISS+1)+RCOR(I,2)                                         0013000
               14*  135  CONTINUE                                                                0014000
               15*       ISP1=ISS+1                                                              0015000
               16*       IE=2=IEE-2                                                              0016000
               17*       DO 140 J=ISP1,IE=2                                                      0017000
               18*       DO 145 I=2,MP1                                                          0018000
               19*       RCOR(I,3)=(-AX(I)*RCOR(I-1,2)-AY(J)*RCOR(I,1)-BB(I,J)*                  0019000
               20*      1RCOR(I,2)-CX(I)*RCOR(I+1,2))/CY(J)                                      0020000
               21*  145  CONTINUE                                                                0021000
               22*       DO 150 I=2,MP1                                                          0022000
               23*       X(I,J+1)=X(I,J+1)+RCOR(I,3)                                             0023000
               24*       RCOR(I,1)=RCOR(I,2)                                                     0024000
               25*       RCOR(I,2)=RCOR(I,3)                                                     0025000
               26*  150  CONTINUE                                                                0026000
               27*  140  CONTINUE                                                                0027000
               28*       RETURN                                                                  0028000
               29*       END                                                                     0029000
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CARD IMAGE FILE EDITOR(CIFEN) -- VERSION 05.29  DATE=10/26/82       TIME=16:16:32:36

<<SPLIT OCEAN1,SOURC1,PRINT,SEQ

     1*        PROGRAM OCEAN                                                          0001000
     2*        PARAMETER M=21,N=21                                                    0002000
     3*        PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                  0003000
     4*        PARAMETER ND=2*M*N1+M1*N1                                              0004000
     5*        DIMENSION DATA1(ND),DATA2(ND),DATA3(ND)                                0005000
     6*        COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                    0006000
     7*       1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                    0007000
     8*       2           B3(M1,N1),P(M1,N1),VZ(M1,N)                                 0008000
     9*        EQUIVALENCE (DATA1,VR1),(DATA2,VR2),(DATA3,VR3)                        0009000
    10*        DATA DATA1/ND*0./,DATA2/ND*0./,DATA3/ND*0./                            0010000
    11*        COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)     0011000
    12*        COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HX(M),ZK(N)      0012000
    13*        COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMO,ITAPE,TBV                       0013000
    14*        CALL INDUMP                                                            0014000
    15*   100  FORMAT(I4)                                                             0015000
    16*        READ(5,100)ITIME                                                       0016000
    17*        READ(5,100)ITER                                                        0017000
    18*        READ(5,100)IOUT                                                        0018000
    19*        READ(5,100)ISMO                                                        0019000
    20*        ISTEP=0                                                                0020000
    21*        READ(5,100)ITAPE                                                       0021000
    22*        CALL INIT                                                              0022000
    23*        IF(ITIME.EQ.0)GO TO 10                                                 0023000
    24* C                                                                            0024000
    25* C                    CONTINUED INTEGRATION FROM A HISTORY TAPE                0025000
    26* C                                                                            0026000
    27*        READ(1)ITIME,DATA1,DATA2,P                                             0027000
    28*        GO TO 20                                                               0028000
    29*    10  CALL START                                                            0029000
    30*    20  XTIME=ITIME*3600.                                                     0030000
    31* C                                                                            0031000
    32* C                    PRINT OLT INITIAL FIELDS                                0032000
    33* C                                                                            0033000
    34*        CALL PUTOUT                                                            0034000
    35*        IF(ITER.EQ.0)STOP                                                      0035000
    36*        DO 90 ISTEP=1,ITER                                                     0036000
    37* C                                                                            0037000
    38* C                    COMPUTE HYDROSTATIC PRESSURE AND DIAGNOSE VERTICAL VE   0038000
    39* C                                                                            0039000
    40*        CALL UP                                                                0040000
    41* C                                                                            0041000
    42* C                 COMPUTE ALL INVISCID TERMS                                 0042000
    43* C                                                                            0043000
    44*        CALL ADVECT                                                            0044000
    45* C                                                                            0045000
    46* C                    COMPUTE VISCOUS TERMS                                   0046000
    47* C                                                                            0047000
    48*        CALL DIFF                                                              0048000
    49* C                                                                            0049000
    50* C                    MARCHING IN TIME                                        0050000
    51* C                    FIRST TIME STEP IS FORWARD IF START IS CALLED           0051000
    52* C                                                                            0052000
    53*        IF(ISTEP.EQ.1.AND.ITIME.EQ.0)DELT=0.5*DELT                             0053000
    54*        CALL FRWRD                                                             0054000
    55*        IF(ISTEP.EQ.1.AND.ITIME.EQ.0)DELT=2.*DELT                              0055000
    56* C                                                                            0056000
    57* C                    DEFINE BOUNDARY VALUES FOR VELOCITY                     0057000
    58* C                                                                            0058000
    59*        CALL BOUNDV                                                            0059000
    60* C                                                                            0060000
    61* C                    CHECK IF DELT IS STABLE                                 0061000
    62* CC                                                                           0062000
    63*        CALL CHECK                                                             0063000
    64*        XTIME=XTIME+DELT                                                       0064000
    65*        ITIME=XTIME/3600.                                                      0065000
    66* C                                                                            0066000
    67* C                    PRINT OLT RESULTS EVERY IOUT STEPS                      0067000
    68* C                                                                            0068000
    69*        IF(MOD(ISTEP,IOLT).EQ.0)CALL PUTOUT                                    0069000
    70* C                                                                            0070000
    71* C                    WRITE HISTORY TAPE EVERY ITAPE STEPS                    0071000
    72* C                                                                            0072000
    73*        IF(MOD(ISTEP,ITAPE).EQ.0)WRITE(2)ITIME,DATA1,DATA2,P                   0073000
    74*    90  CONTINUE                                                             0074000
    75*        STOP                                                                   0075000
    76*        END                                                                    0076000
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CARD IMAGE FILE EDITOR(CIFEN) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER INIT

      1*       SUBROUTINE  INIT                                                  0001000
      2*       PARAMETER M=21,N=21                                               0002000
      3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                             0003000
      4*       COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),               0004000
      5*      1          VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),               0005000
      6*      2          B3(M1,N1),P(M1,N1),VZ(M1,N)                            0006000
      7*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N) 0007000
      8*       COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,RK(M),ZK(N) 0008000
      9*       COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMO,ITAPE,TBV                  0009000
     10* C                                                                       0010000
     11* C                    INITIALIZE ALL DEPENDENT VARIABLES AND CONSTANTS    0011000
     12* C                                                                       0012000
     13* C                                                                       0013000
     14* C                     ALPHA IS THE NONDIMENSIONAL SMOOTHING COEF.        0014000
     15* C                     FOR TIME SMOOTHING IN SUBROUTINE FRWRD             0015000
     16* C                                                                       0016000
     17*       DELT=900.                                                         0017000
     18*       ALPHA=0.10                                                        0018000
     19*       G=980.                                                            0019000
     20*       LAT=30                                                            0020000
     21*       CORI=2.*7.2722E-5*SIN(LAT*3.14159/180.)                           0021000
     22* C                                                                       0022000
     23* C                     DEFINE RADII AT GRID POINTS AND ALL GRID INTERVALS 0023000
     24* C                                                                       0024000
     25*       DO 10 I=1,M1                                                      0025000
     26*    10 DR1(I)=20.E5                                                      0026000
     27*       R1(1)=0.                                                          0027000
     28*       DO 20 I=2,M                                                       0028000
     29*    20 R1(I)=R1(I-1)+DR1(I-1)                                            0029000
     30*       DO 30 I=1,M1                                                      0030000
     31*    30 R2(I)=0.5*(R1(I)+R1(I+1))                                         0031000
     32*       DR2(1)=2.*(R2(1)-R1(1))                                           0032000
     33*       DR2(M)=2.*(R1(M)-R2(M1))                                          0033000
     34*       DO 40 I=2,M1                                                      0034000
     35*    40 DR2(I)=R2(I)-R2(I-1)                                              0035000
     36* C     MAX=MAXMAG(DR1)                                                   0036000
     37* C     DRMAX=DR1(MAX)                                                    0037000
     38* C                                                                       0038000
     39* C                     DEFINE ALL DZ'S                                   0039000
     40* C                                                                       0040000
     41*       DO 100 J=1,N                                                      0041000
     42*   100 Z1(J)=(J-1)*200.E2                                                0042000
     43*       DO 110 J=1,N1                                                     0043000
     44*   110 DZ1(J)=Z1(J+1)-Z1(J)                                              0044000
     45*       DZ2(1)=2.*(0.5*DZ1(1)-Z1(1))                                      0045000
     46*       Z2(1)=0.5*DZ2(1)                                                  0046000
     47*       DO 120 J=2,N1                                                     0047000
     48*       DZ2(J)=0.5*(DZ1(J)+DZ1(J-1))                                      0048000
     49*   120 Z2(J)=Z2(J-1)+DZ2(J)                                              0049000
     50*       DZ2(N)=2.*(Z1(N)-Z1(N-1)-0.5*DZ1(N1))                             0050000
     51* C                                                                       0051000
     52* C                     A AND B ARE CONSTANT USED IN SUBROUTINE BRUNDV     0052000
     53* C                     FOR CONSTANT DIV. AND VORT. CONDITIONS            0053000
     54* C                                                                       0054000
     55*       BNDA=R1(M1)/R1(M)                                                 0055000
     56*       BNDB=(R1(M1)+R1(M))*DR1(M1)/((R1(M1)+R1(M2))*R1(M)*DR1(M2))       0056000
     57*       BNDB=0.                                                           0057000
     58* C                                                                       0058000
     59* C                     DEFINE DENSITY RELATED CONSTANTS                  0059000
     60* C                                                                       0060000
     61*       RHO=1.                                                            0061000
     62*       DO 130 J=1,N                                                      0062000
     63*   130 BV2(J)=1.E-6                                                      0063000
     64*       TBV=0.                                                            0064000
     65*       DO 135 J=1,N                                                      0065000
     66*   135 TBV=AMAX1(TBV,BV2(J))                                             0066000
     67*       TBV=1./SQRT(TBV)                                                  0067000
     68* C                                                                       0068000
     69* C                     DEFINE HORIZONTAL AND VERTICAL DIFFUSION COEFFIENTS 0069000
     70* C                                                                       0070000
     71*       COEFH=0.002*DR1(1)**2/DELT                                        0071000
     72*       COEFZ=0.001*DZ1(1)**2/DELT                                        0072000
     73*       DO 140 I=1,M1                                                     0073000
     74*   140 RK(I)=COEFH*(1.+5.*EXP(-FLOAT(M1-I)/7.))                          0074000
     75*       DO 150 J=1,N1                                                     0075000
     76*   150 ZK(J)=COEFZ*(1.+5.*(EXP(-FLOAT(J-1)/5.)+EXP(-FLOAT(N1-J)/5.)))   0076000
     77*       RETURN                                                            0077000
     78*       END                                                               0078000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER START

  1*       SUBROUTINE START                                                      0001000
  2*       PARAMETER M=21,N=21                                                   0002000
  3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                 0003000
  4*       COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                   0004000
  5*      1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                  0005000
  6*      2           B3(M1,N1),P(M1,N1),VZ(M1,N)                               0006000
  7*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)    0007000
  8*       COMMON/THR/RH0,RH0R(N1),BVZ(N),ALPHA,ENDA,BNDB,CORI,G,HK(M),ZK(N)     0008000
  9*       PARAMETER NO=2*M*N1+M1*N1                                             0009000
 10*       DIMENSION DATA1(NO),DATA2(NO)                                         0010000
 11*       EQUIVALENCE (DATA1,VR1),(DATA2,VR2)                                   0011000
 12* C                                                                           0012000
 13* C                    INITIALIZE MASS FIELDS FOR A THEORETICAL RING          0013000
 14* C                                                                           0014000
 15*       I11=1                                                                 0015000
 16*       I12=13                                                                0016000
 17*       I21=I12+1                                                             0017000
 18*       I22=M1                                                                0018000
 19*       BMAG=0.0002                                                           0019000
 20*       DO 10 I=I11,I12                                                       0020000
 21*    10 B1(I,N1)=BMAG*COS(FLOAT(I-I11)/8.*3.1459)*G/RH0                       0021000
 22*       DO 30 I=I21,I22                                                       0022000
 23*    30 B1(I,N1)=B1(I12,N1)*EXP(-FLOAT(I-I21+1)/4.)                           0023000
 24*       DO 40 J=1,N2                                                          0024000
 25*       FACT=EXP(FLOAT(J-N1)/5.)                                              0025000
 26*       DO 40 I=1,M1                                                          0026000
 27*    40 B1(I,J)=B1(I,N1)*FACT                                                 0027000
 28* C                                                                           0028000
 29* C                    PRESSURE IS OBTAINED HYDROSTATICALLY FROM BUOYANCY     0029000
 30* C                                                                           0030000
 31*       DO 50 I=1,M1                                                          0031000
 32*    50 P(I,1)=-0.5*RH0*DZ2(1)*B1(I,1)                                        0032000
 33*       DO 60 J=2,N1                                                          0033000
 34*       DO 60 I=1,M1                                                          0034000
 35*    60 P(I,J)=P(I,J-1)-0.5*RH0*DZ2(J)*(B1(I,J)+B1(I,J-1))                    0035000
 36* C                                                                           0036000
 37* C                    TANGENTIAL VELOCITY IS AT GRADIENT BALANCE             0037000
 38* C                                                                           0038000
 39*       DO 70 J=1,N1                                                          0039000
 40*       DO 70 I=2,M1                                                          0040000
 41*       PGF=(P(I,J)-P(I-1,J))/(RH0*DR2(I))                                    0041000
 42*       RAD=(0.5*CORI*R1(I))**2+R1(I)*PGF                                     0042000
 43*       JJ=J                                                                  0043000
 44*       II=I                                                                  0044000
 45*       IF(RAD.LT.0.)GO TO 100                                                0045000
 46*    70 VT1(I,J)=-0.5*CORI*R1(I)+SQRT(RAD)                                    0046000
 47* C                                                                           0047000
 48* C                    SET DATA2=DATA1 FOR LEAPFROG                           0048000
 49* C                                                                           0049000
 50*       DO 80 I=1,NO                                                          0050000
 51*    80 DATA2(I)=DATA1(I)                                                     0051000
 52*       CALL BRUNOV                                                           0052000
 53*       DO 90 I=1,NO                                                          0053000
 54*    90 DATA1(I)=DATA2(I)                                                     0054000
 55*       RETURN                                                                0055000
 56*   100 PRINT 110,II,JJ,PGF,RAD                                              0056000
 57*   110 FORMAT(' RADICAL IN SUBROUTINE START IS NEGATIVE AT (I,J)=',2I5,      0057000
 58*      1' PGF, RAD =',1P2E12.3)                                               0058000
 59*       STOP                                                                  0059000
 60*       END                                                                   0060000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=16:16:32:36

*** MEMBER UP

      1*       SUBROUTINE UP                                                          0001000
      2*       PARAMETER M=21,N=21                                                    0002000
      3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                  0003000
      4*       COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                    0004000
      5*      1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                    0005000
      6*      2           B3(M1,N1),P(M1,N1),VZ(M1,N)                                 0006000
      7*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)     0007000
      8*       COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N)      0008000
      9*       PARAMETER MIN=M1+A                                                     0009000
     10*       DATA VZ/MIN*0./                                                        0010000
     11* C                                                                           0011000
     12* C                    PRESSURE IS OBTAINED HYDROSTATICALLY FROM B             0012000
     13* C                                                                           0013000
     14*       DO 10 I=1,M1                                                           0014000
     15*    10 P(I,1)=-0.5*RHO*DZ2(I)*B2(I,1)                                         0015000
     16*       DO 20 J=2,N1                                                           0016000
     17*       DO 20 I=1,M1                                                           0017000
     18*    20 P(I,J)=P(I,J-1)-0.5*RHO*DZ2(J)*(B2(I,J)+B2(I,J-1))                     0018000
     19* C                                                                           0019000
     20* C                    DIAGNOSE VERTICAL VELOCITY BY CONTINUITY EQUATION       0020000
     21* C                                                                           0021000
     22*       DO 30 J=2,N1                                                           0022000
     23*       DO 30 I=1,M1                                                           0023000
     24*    30 VZ(I,J)=VZ(I,J-1)+DZ1(J)*(R1(I+1)*VR2(I+1,J-1)-R1(I)*VR2(I,J-1))       0024000
     25*      1        /(DR1(I)*0.5*(R1(I+1)+R1(I)))                                0025000
     26*       RETURN                                                                 0026000
     27*       END                                                                    0027000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER BOUNDV

                1*      SUBROUTINE BOUNLV                                                       0001000
                2*      PARAMETER M=21,N=21                                                     0002000
                3*      PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                   0003000
                4*      COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                     0004000
                5*     1          VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                     0005000
                6*     2          B3(M1,N1),P(M1,N1),VZ(M1,N)                                  0006000
                7*      COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)      0007000
                8*      COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,MK(M),ZK(N)       0008000
                9* C                                                                             0009000
               10* C                  LATERAL BOUNDARY FOR TANGENTIAL AND RADIAL VELOCITIES     0010000
               11* C                  ASSUMING CONTINUOUS VORTICITY AND DIVERGENCE               0011000
               12* C                                                                             0012000
               13*      DO 10 J=1,N1                                                            0013000
               14*      VR2(M,J)=BNDA*VR2(M1,J)+BNDB*(R1(M1)*VR2(M1,J)-R1(M2)*VR2(M2,J))        0014000
               15*   10 VT2(M,J)=BNDA*VT2(M1,J)+BNDB*(R1(M1)*VT2(M1,J)-R1(M2)*VT2(M2,J))        0015000
               16*      RETURN                                                                  0016000
               17*      END                                                                     0017000
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CARD IMAGE FILE EDITOR(CIFER) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER DIFF

      SUBROUTINE DIFF                                                          0001000
C                                                                              0002000
C                     COMPLTE THE DIFFUSION TERMS                              0003000
C                                                                              0004000
      PARAMETER M=21,N=21                                                      0005000
      PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                    0006000
      COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                      0007000
     1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                      0008000
     2           B3(M1,N1),P(M1,N1),VZ(M1,N)                                   0009000
      COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)       0010000
      COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N)        0011000
      DIMENSION VR(M,N1),VT(M,N1),B(M1,N1)                                     0012000
      EQUIVALENCE (VR,VR1),(VT,VT1),(B,B1)                                     0013000
C                                                                              0014000
C                     HORIZONTAL DIFFUSION OF RADIAL VELOCITY                  0015000
C                                                                              0016000
      DO 10 J=1,N1                                                             0017000
      DO 10 I=2,M1                                                             0018000
   10 VR3(I,J)=VR3(I,J)+HK(I)*(((VR(I+1,J)-VR(I,J))/DR1(I)                     0019000
     1        -(VR(I,J)-VR(I-1,J))/DR1(I-1))/DR2(I)-VR(I,J)/(R1(I)*R1(I)))     0020000
     2          +0.5*((VR(I+1,J)-VR(I,J))/(DR1(I)*R2(I))                      0021000
     3          +(VR(I,J)-VR(I-1,J))/(DR1(I-1)*R2(I-1))))                     0022000
C                                                                              0023000
C                     HORIZONTAL DIFFUSION OF TANGENTIAL VELOCITY              0024000
C                                                                              0025000
      DO 20 J=1,N1                                                             0026000
      DO 20 I=2,M1                                                             0027000
   20 VT3(I,J)=VT3(I,J)+HK(I)*(((VT(I+1,J)-VT(I,J))/DR1(I)                     0028000
     1        -(VT(I,J)-VT(I-1,J))/DR1(I-1))/DR2(I)-VT(I,J)/(R1(I)*R1(I)))     0029000
     2          +0.5*((VT(I+1,J)-VT(I,J))/(DR1(I)*R2(I))                      0030000
     3          +(VT(I,J)-VT(I-1,J))/(DR1(I-1)*R2(I-1))))                     0031000
C                                                                              0032000
C                     HORIZONTAL DIFFUSION OF B                                0033000
C                                                                              0034000
      DO 60 J=1,N1                                                             0035000
      DO 60 I=2,M2                                                             0036000
   60 B3(I,J)=B3(I,J)+HK(I)*(((B(I+1,J)-B(I,J))/DR2(I+1)                       0037000
     1          -(B(I,J)-B(I-1,J))/DR2(I))/DR1(I)                             0038000
     2          +0.5*((B(I+1,J)-B(I,J))/(DR2(I+1)*R1(I+1))                    0039000
     3          +(B(I,J)-B(I-1,J))/(DR2(I)*R1(I))))                           0040000
      DO 70 J=1,N1                                                             0041000
   70 B3(1,J)=B3(1,J)+HK(1)*((B(2,J)-B(1,J))/(DR2(2)*DR1(1))                   0042000
     1          +0.5*(B(2,J)-B(1,J))/(DR2(2)*R1(2)))                          0043000
      DO 80 J=1,N1                                                             0044000
   80 B3(M1,J)=B3(M1,J)+HK(M1)*((-B(M1,J)+B(M2,J))/(DR2(M1)*DR1(M1))           0045000
     1          -(B(M1,J)-B(M2,J))/(DR2(M1)*R1(M1)))                          0046000
C                                                                              0047000
C                     VERTICAL DIFFUSION OF RADIAL VELOCITY                    0048000
C                                                                              0049000
      DO 90 J=2,N2                                                             0050000
      DO 90 I=2,M1                                                             0051000
   90 VR3(I,J)=VR3(I,J)+ZK(J)*((VR(I,J+1)-VR(I,J))/DZ2(J+1)                    0052000
     1          -(VR(I,J)-VR(I,J-1))/DZ2(J))/DZ1(J)                           0053000
      DO 100 I=2,M1                                                            0054000
  100 VR3(I,1)=VR3(I,1)+ZK(1)*(VR(I,2)-VR(I,1))/(DZ2(2)*DZ1(1))                0055000
      DO 110 I=2,M1                                                            0056000
  110 VR3(I,N1)=VR3(I,N1)+ZK(N1)*(-VR(I,N1)+VR(I,N2))/(DZ2(N1)*DZ1(N1))        0057000
C                                                                              0058000
C                     VERTICAL DIFFUSION OF TANGENTIAL VELOCITY                0059000
C                                                                              0060000
      DO 120 J=2,N2                                                            0061000
      DO 120 I=2,M1                                                            0062000
  120 VT3(I,J)=VT3(I,J)+ZK(J)*((VT(I,J+1)-VT(I,J))/DZ2(J+1)                    0063000
     1          -(VT(I,J)-VT(I,J-1))/DZ2(J))/DZ1(J)                           0064000
      DO 130 I=2,M1                                                            0065000
  130 VT3(I,1)=VT3(I,1)+ZK(1)*(VT(I,2)-VT(I,1))/(DZ2(2)*DZ1(1))                0066000
      DO 140 I=2,M1                                                            0067000
  140 VT3(I,N1)=VT3(I,N1)+ZK(N1)*(-VT(I,N1)+VT(I,N2))/(DZ2(N1)*DZ1(N1))        0068000
                                                                               0069000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER DIFF

      70* C                                                                    0070000
      71* C                    VERTICAL DIFFUSION OF B                         0071000
      72* C                                                                    0072000
      73*       DO 160 J=2,N2                                                  0073000
      74*       DO 160 I=1,M1                                                  0074000
      75*   160 B3(I,J)=B3(I,J)+ZK(J)*((B1(I,J+1)-B(I,J))/DZ2(J+1)             0075000
      76*      1          -(B(I,J)-B(I,J-1))/DZ2(J))/DZ1(J)                   0076000
      77*       DO 170 I=1,M1                                                  0077000
      78*   170 B3(I,1)=B3(I,1)+ZK(1)*(B(I,2)-B(I,1))/(DZ2(2)*DZ1(1))          0078000
      79*       DO 180 I=1,M1                                                  0079000
      80*   180 B3(I,N1)=B3(I,N1)+ZK(N1)*(-B(I,N1)+B(I,N2))/(DZ2(N1)*DZ1(N1))  0080000
      81*       RETURN                                                         0081000
      82*       END                                                            0082000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER FRWRD

 1*        SUBROUTINE FRWRD                                                      0001000
 2*        PARAMETER M=21,N=21                                                   0002000
 3*        PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                 0003000
 4*        PARAMETER ND=2*M*N1+M1*N1                                             0004000
 5*        COMMON/ONE/DATA1(ND),DATA2(ND),DATA3(ND),P(M1,N1),VZ(M1,N)            0005000
 6*        COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HH(M),ZK(N)     0006000
 7*        COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISHO,ITAPE,TBV                      0007000
 8* C                                                                            0008000
 9* C                    REPLACE DATA3 WITH THE NEW VALUES                       0009000
10* C                                                                            0010000
11*        DO 10 I=1,ND                                                          0011000
12*    10 DATA3(I)=DATA1(I)+2.*DELT*DATA3(I)                                     0012000
13* C                                                                            0013000
14* C                    TIME SMOOTHING                                          0014000
15* C                                                                            0015000
16*        IF(MOD(ISTEP,ISHO),NE.0)GO TO 30                                      0016000
17*        DO 20 I=1,ND                                                          0017000
18*    20 DATA2(I)=DATA2(I)+(DATA1(I)+DATA3(I)-2.*DATA2(I))*ALPHA                0018000
19*    30 CONTINUE                                                               0019000
20* C                                                                            0020000
21* C                    FORWARD MARCHING                                        0021000
22* C                                                                            0022000
23*        DO 40 I=1,ND                                                          0023000
24*    40 DATA1(I)=DATA2(I)                                                      0024000
25*        DO 50 I=1,NC                                                          0025000
26*    50 DATA2(I)=DATA3(I)                                                      0026000
27* C                                                                            0027000
28* C                     ZERO OUT DATA3 FOR NEXT STEP                           0028000
29* C                                                                            0029000
30*        DO 60 I=1,NC                                                          0030000
31*    60 DATA3(I)=0.                                                            0031000
32*        RETURN                                                                0032000
33*        END                                                                   0033000
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CARU IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/26/82       TIME=14:16:32:36

*** MEMBER CHECK

  1*        SUBROUTINE CHECK                                                      0001000
  2*        PARAMETER MM21,NN21                                                   0002000
  3*        PARAMETER M1=M=1,M2=M=2,N1=N=1,N2=N=2                                 0003000
  4*        COMMON/RAE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                   0004000
  5*       1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                   0005000
  6*       2           B3(M1,N1),P(M1,N1),VZ(M1,N)                                0006000
  7*        COMMON/TW9/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)    0007000
  8*        COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMP,ITAPE,TOV                      0008000
  9*        DIMENSION WORK1(M),WORK2(N)                                           0009000
 10*        DO 10 J=1,N1                                                          0010000
 11*        DO 20 I=1,M                                                           0011000
 12*     20 WORK1(I)=DR2(I)/AMAX1(1.,VR2(I,J))                                    0012000
 13*        MIN=MININMAG(WORK1)+1                                                 0013000
 14*        DT=WORK1(MIN)*0.9                                                     0014000
 15*        DT=AMIN1(DT,DELT)                                                     0015000
 16*     10 CONTINUE                                                              0016000
 17*        DT=AMIN1(DT,TOV)                                                      0017000
 18*        IF(DT.GE.DELT)RETURN                                                  0018000
 19*        DELT=0.75*DELT                                                        0019000
 20*        PRINT 100,DELT                                                        0020000
 21*    100 FORMAT(///////,'********DELT IS CHANGED TO',1PE11.2,' **********')   0021000
 22*        RETURN                                                                0022000
 23*        END                                                                   0023000
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CARD IMAGE FILE EDITOR(CIFEM) -- VERSION 05.29  DATE=10/20/82       TIME=14:16:32:36

*** MEMBER ADVECT

 1*       SUBROUTINE ADVECT                                                      0001000
 2* C                                                                            0002000
 3* C                    COMPUTE THE ADVECTIVE TERMS                             0003000
 4* C                                                                            0004000
 5*       PARAMETER M=21,N=21                                                    0005000
 6*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                  0006000
 7*       COMMON/ONE/VR1(M,N1),VT1(M,N1),B1(M1,N1),VR2(M,N1),                    0007000
 8*      1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                  0008000
 9*      2           B3(M1,N1),P(M1,N1),VZ(M1,N)                               0009000
10*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)    0010000
11*       COMMON/THR/RHO,HH0R(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HH(M),ZK(N)     0011000
12*       DIMENSION VR(M,N1),VT(M,N1),B(M1,N1)                                   0012000
13*       EQUIVALENCE (VR,VR2),(VT,VT2),(B,B2)                                   0013000
14* C                                                                            0014000
15* C                    HORIZONTAL ADVECTION FOR RADIAL VELOCITY                0015000
16* C                                                                            0016000
17*       DO 10 J=1,N1                                                           0017000
18*       DO 10 I=2,M1                                                           0018000
19*    10 VR3(I,J)=-0.25*((VR(I,J)+VR(I-1,J))*(VR(I,J)-VR(I-1,J))/DR1(I-1)       0019000
20*      1          +(VR(I+1,J)+VR(I,J))*(VR(I+1,J)-VR(I,J))/DR1(I))           0020000
21*      2          +VR3(I,J)                                                  0021000
22* C                                                                            0022000
23* C                    HORIZONTAL ADVECTION FOR TANGENTIAL VELOCITY            0023000
24* C                                                                            0024000
25*       DO 20 J=1,N1                                                           0025000
26*       DO 20 I=2,M1                                                           0026000
27*    20 VT3(I,J)=-0.25*((VR(I,J)+VR(I-1,J))*(VT(I,J)-VT(I-1,J))/DR1(I-1)       0027000
28*      1          +(VR(I+1,J)+VR(I,J))*(VT(I+1,J)-VT(I,J))/DR1(I))           0028000
29*      2          +VT3(I,J)                                                  0029000
30* C                    HORIZONTAL ADVECTION FOR BUOYANCY                       0030000
31* C                                                                            0031000
32*       DO 60 J=1,N1                                                           0032000
33*       DO 60 I=2,M2                                                           0033000
34*    60 B3(I,J)=B3(I,J)-0.5*(VR(I,J)*(B(I,J)-B(I-1,J))/DR2(I)                  0034000
35*      1          +VR(I+1,J)*(B(I+1,J)-B(I,J))/DR2(I+1))                     0035000
36*       DO 70 J=1,N1                                                           0036000
37*    70 B3(1,J)=B3(1,J)-0.5*VR(2,J)*(B(2,J)-B(1,J))/DR2(2)                     0037000
38*       DO 80 J=1,N1                                                           0038000
39*    80 B3(M1,J)=B3(M1,J)-0.5*VR(M1,J)*(B(M1,J)-B(M2,J))/DR2(M1)               0039000
40* C                                                                            0040000
41* C                    VERTICAL ADVECTION FOR RADIAL VELOCITY                  0041000
42* C                                                                            0042000
43*       DO 90 J=2,N2                                                           0043000
44*       DO 90 I=2,M1                                                           0044000
45*    90 VR3(I,J)=VR3(I,J)-0.25*((VZ(I-1,J)+VZ(I,J))*(VR(I,J)-VR(I,J-1))       0045000
46*      1          /DZ2(J)+(VZ(I,J+1)+VZ(I-1,J+1))*(VR(I,J+1)-VR(I,J))        0046000
47*      2          /DZ2(J+1))                                                 0047000
48*       DO 95 I=2,M1                                                           0048000
49*    95 VR3(I,1)=VR3(I,1)-0.25*(VZ(I,2)+VZ(I-1,2))*(VR(I,2)-VR(I,1))          0049000
50*      1          /DZ2(2)                                                    0050000
51*       DO 96 I=2,M1                                                           0051000
52*    96 VR3(I,N1)=VR3(I,N1)-0.25*(VZ(I-1,N1)+VZ(I,N1))*(VR(I,N1)-VR(I,N2))    0052000
53*      1          /DZ2(N1)                                                   0053000
54* C                                                                            0054000
55* C                    VERTICAL ADVECTION FOR TANGENTIAL VELOCITY              0055000
56* C                                                                            0056000
57*       DO 100 J=2,N2                                                          0057000
58*       DO 100 I=2,M1                                                          0058000
59*   100 VT3(I,J)=VT3(I,J)-0.25*((VZ(I-1,J)+VZ(I,J))*(VT(I,J)-VT(I,J-1))       0059000
60*      1          /DZ2(J)+(VZ(I,J+1)+VZ(I-1,J+1))*(VT(I,J+1)-VT(I,J))        0060000
61*      2          /DZ2(J+1))                                                 0061000
62*       DO 105 I=2,M1                                                          0062000
63*   105 VT3(I,1)=VT3(I,1)-0.25*(VZ(I,2)+VZ(I-1,2))*(VT(I,2)-VT(I,1))          0063000
64*      1          /DZ2(2)                                                    0064000
65*       DO 106 I=2,M1                                                          0065000
66*   106 VT3(I,N1)=VT3(I,N1)-0.25*(VZ(I,N1)+VZ(I-1,N1))*(VT(I,N1)-VT(I,N2))    0066000
67*      1          /DZ2(N1)                                                   0067000
68* C                                                                            0068000
69* C                    VERTICAL ADVECTION FOR B                                0069000
70* C                                                                            0070000
71*       DO 150 J=2,N2                                                          0071000
72*       DO 150 I=1,M1                                                          0072000
73*   150 B3(I,J)=B3(I,J)-0.5*(VZ(I,J)*(B(I,J)-B(I,J-1))/DZ2(J)                  0073000
74*      1          +VZ(I,J+1)*(B(I,J+1)-B(I,J))/DZ2(J+1))                     0074000
75*       DO 160 I=1,M1                                                          0075000
76*   160 B3(I,1)=B3(I,1)-0.5*VZ(I,2)*(B2(I,2)-B2(I,1))/DZ2(2)                   0076000
77*       DO 170 I=1,M1                                                          0077000
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CARD IMAGE FILE EDITOR(CIFER) -- VERSION 05.29  DATE=10/20/82       TIME=14:16:32:36

*** MEMBER ADVECT

     78*   170 B3(I,N1)=B3(I,N1)-0.5*VZ(I,N1)*(B(I,N1)-B(I,N2))/DZ2(N1)          0078000
     79* C                                                                       0079000
     80* C                    INERTIA TERMS FOR HORIZONTAL MOMENTUM               0080000
     81* C                                                                       0081000
     82*         DO 110 J=1,N1                                                   0082000
     83*         DO 110 I=2,M1                                                   0083000
     84*         VR3(I,J)=VR3(I,J)+VT(I,J)*(VT(I,J)/R1(I)+CORI)                  0084000
     85*   110 VT3(I,J)=VT3(I,J)-VR(I,J)*(VT(I,J)/R1(I)+CORI)                    0085000
     86* C                                                                       0086000
     87* C                     PRESSURE GRADIENT FORCE                           0087000
     88* C                                                                       0088000
     89*         DO 120 J=1,N1                                                   0089000
     90*         DO 120 I=2,M1                                                   0090000
     91*   120 VR3(I,J)=VR3(I,J)-(P(I,J)-P(I-1,J))/(RHO*DR2(I))                  0091000
     92* C                                                                       0092000
     93* C                     STRATIFICATION TERM                               0093000
     94* C                                                                       0094000
     95*         DO 130 J=1,N1                                                   0095000
     96*         DO 130 I=1,M1                                                   0096000
     97*   130 B3(I,J)=B3(I,J)+0.5*(V2(I,J)*BV2(J)+VZ(I,J+1)*BV2(J+1))           0097000
     98*         RETURN                                                          0098000
     99*         END                                                             0099000
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CARD IMAGE FILE EDITOR(CIFEH) -- VERSION 05.29  DATE=10/20/82       TIME=14:16:32:36

*** MEMBER PUTOUT

 1*       SUBROUTINE PUTOLT                                                      0001000
 2*       PARAMETER M=21,N=21                                                    0002000
 3*       PARAMETER M1=M-1,M2=M-2,N1=N-1,N2=N-2                                  0003000
 4*       COMMON/ONE/VR1(M,N1),VTI(M,N1),R1(M1,N1),VR2(M,N1),                    0004000
 5*      1           VT2(M,N1),B2(M1,N1),VR3(M,N1),VT3(M,N1),                  0005000
 6*      2           B3(M1,N1),P(M1,N1),VZ(M1,N)                               0006000
 7*       COMMON/TWO/R1(M),R2(M1),DR1(M1),DR2(M),Z1(N),Z2(N1),DZ1(N1),DZ2(N)     0007000
 8*       COMMON/THR/RHO,RHOR(N1),BV2(N),ALPHA,BNDA,BNDB,CORI,G,HK(M),ZK(N)      0008000
 9*       COMMON/FOR/DELT,XTIME,ITIME,ISTEP,ISMD,ITAPE,TBV                       0009000
10* C                                                                            0010000
11* C                    THIS SUBROUTINE PRINT OLT FIELDS FOR A QUICK LOOK       0011000
12* C                                                                            0012000
13*       DIMENSION IDUM(M,N)                                                    0013000
14*   700 FORMAT(/////,'  RADIAL VELOCITY (CM/S) AT T=',I6,' H')                 0014000
15*   705 FORMAT(/////,'  TANGENTIAL VELOCITY (CM/S) AT T=',I6,' H')             0015000
16*   710 FORMAT(/////,'  VERTICAL VELOCITY (CM/S) AT T=',I6,' H')               0016000
17*   715 FORMAT(/////,'  BUOYANCY FIELD (*.001) AT T=',I6,' H')                 0017000
18*   725 FORMAT(/////,'  PRESSURE (*10 DYNE/CM**2) AT TIME=',I6,' H')           0018000
19*   720 FORMAT(1H1,////,20X,'++++++++++   OLTPUT AT TIME =',I6,' H    DR',     0019000
20*      1 F8.2,' DAY     ISTEP =',I7,'    ++++++++++++++')                     0020000
21*       DAY=ITIME/86400.+0.0001                                                0021000
22*       PRINT 720,ITIME,DAY,ISTEP                                              0022000
23*       DO 10 J=1,N1                                                           0023000
24*       DO 10 I=1,M                                                            0024000
25*    10 IDUM(I,J)=VR2(I,J)                                                     0025000
26*       PRINT 700,ITIME                                                        0026000
27*       CALL MAP(IDUM,R1,22,M,N1)                                              0027000
28*       DO 20 J=1,N1                                                           0028000
29*       DO 20 I=1,M                                                            0029000
30*    20 IDUM(I,J)=VT2(I,J)                                                     0030000
31*       PRINT 705,ITIME                                                        0031000
32*       CALL MAP(IDUM,R1,22,M,N1)                                              0032000
33*       DO 30 J=1,N                                                            0033000
34*       DO 30 I=1,M1                                                           0034000
35*    30 IDUM(I,J)=VZ(I,J)                                                      0035000
36*       PRINT 710,ITIME                                                        0036000
37*       CALL MAP(IDUM,R2,Z1,M1,N)                                              0037000
38*       DO 40 J=1,N1                                                           0038000
39*       DO 40 I=1,M1                                                           0039000
40*    40 IDUM(I,J)=B2(I,J)+1.E3                                                 0040000
41*       PRINT 715,ITIME                                                        0041000
42*       CALL MAP(IDUM,R2,Z2,M1,N1)                                             0042000
43*       DO 50 J=1,N1                                                           0043000
44*       DO 50 I=1,M1                                                           0044000
45*    50 IDUM(I,J)=P(I,J)+1.E-1                                                 0045000
46*       PRINT 725,ITIME                                                        0046000
47*       CALL MAP(IDUM,R2,Z2,M1,N1)                                             0047000
48*       RETURN                                                                 0048000
49*       END                                                                    0049000
```

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CARD IMAGE FILE EDITOR(CIFED) ** VERSION 05.29  DATE=10/26/82       TIME=14:11:32:36

*** MEMBER MAP

                1*        SUBROUTINE MAP(A,R,Z,MM,NN)                                    0001000
                2*        PARAMETER MP=21,NP=4                                           0002000
                3*        DIMENSION R(MM),Z(NN)                                          0003000
                4*        INTEGER A (M,N),IR(M),IZ(N)                                    0004000
                5*     70 FORMAT(1HS,7X,25I5)                                            0005000
                6*     80 FORMAT(1HS,I4,3X,25I5)                                         0006000
                7*        MP=MIN0(25,MM)                                                 0007000
                8*        DO 10 I=1,MP                                                   0008000
                9*     10 IR(I)=R(I)+1.E-5+0.1                                           0009000
               10*        DO 20 J=1,NN                                                   0010000
               11*     20 IZ(J)=Z(J)+1.E-2+0.1                                           0011000
               12*        PRINT 70                                                       0012000
               13*        PRINT 70,(IR(I),I=1,MP)                                        0013000
               14*        PRINT 70                                                       0014000
               15*        DO 30 JJ=1,NN                                                  0015000
               16*        J=NN+1-JJ                                                      0016000
               17*     30 PRINT 80,IZ(J),(A(I,J),I=1,MP)                                 0017000
               18*        RETURN                                                         0018000
               19*        END                                                            0019000
```

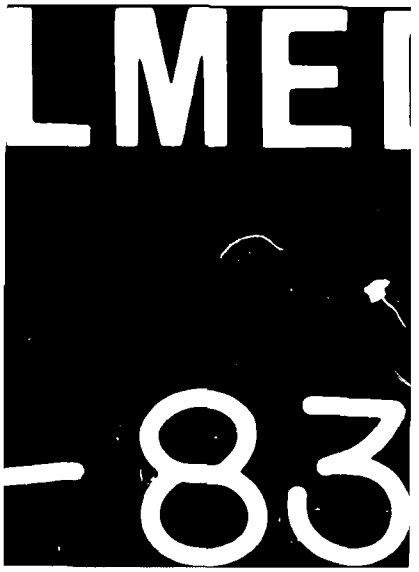
LME
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